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Bioventing Pilot Test Work Plan for Sites 27, 28, and 44 Nellis AFB, Nevada

PART II

Draft Interim Pilot Test Results Report for Sites 27, 28, and 44 Nellis AFB, Nevada

Prepared For

Air Force Center for Environmental Excellence
Brooks AFB, Texas

and

USAFWTC/EVR
Nellis AFB, Nevada

ES ENGINEERING-SCIENCE

ES
Engineering-Science, Inc.

1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290

March 1994

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PART I

BIOVENTING PILOT TEST WORK PLAN FOR SITES 27, 28, AND 44

NELLIS AFB, NEVADA

March 1994

Prepared for:

Air Force Center for Environmental Excellence
Brooks AFB, Texas

and

USAFWTC/EVR
Nellis AFB, Nevada

Prepared by:

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1700 Broadway, Suite 900
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FIGURES

PART I

BIOVENTING PILOT TEST WORK PLAN FOR SITES 27, 28, AND 44 NELLIS AFB, NEVADA

1.0 INTRODUCTION

This work plan presents the scope of multiphase bioventing pilot tests for *in situ* treatment of fuel-contaminated soils at Sites 27, 28, and 44 at Nellis Air Force Base (AFB), Nevada. The pilot tests will be performed by Engineering-Science, Inc. (ES). The three primary objectives of the proposed pilot tests are: 1) to assess the potential for supplying oxygen throughout the contaminated soil interval, 2) to determine the rate at which indigenous microorganisms will degrade fuel when supplied with oxygen-rich soil gas, and 3) to evaluate the potential for sustaining these rates of biodegradation until fuel contamination is remediated to concentrations below regulatory standards.

The pilot tests will be conducted in two phases. A vent well (VW) and vapor monitoring points (MPs) will be installed during site investigation activities. The initial test phase at each site will also include an *in situ* respiration test, an air permeability test, and installation of a blower system for air injection. This initial testing is expected to take approximately 3 weeks. If the initial phase is successful, the second phase will begin immediately. During the second phase, the bioventing systems will be operated and monitored over a 1-year period.

If bioventing proves to be an effective means of remediating soil contamination at these sites, pilot test data may be used to design full-scale remediation systems and to estimate the time required for site cleanup. An added benefit of the pilot testing at the sites is that a significant amount of the fuel contamination should be biodegraded during the 1-year pilot test, as the testing will take place within the most contaminated soils at the sites. Additional background information on the development and recent success of the bioventing technology is found in the document entitled *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Hinchee et al., 1992). This protocol document will serve as the primary reference for pilot test well designs and the detailed procedures to be used during the test.

2.0 SITE DESCRIPTIONS

2.1 Site 27

2.1.1 Site History and Location

Site 27 is located at Facility 1014 northwest of Las Vegas Boulevard (Figure 2.1). The pilot test area is just to the southwest of the boundary fence for the fuel yard (Figure 2.2). Site 27 is the location of a reported leak from a waste petroleum, oils, and lubricants (POL) tank. Four 20,000-gallon underground storage tanks (USTs) were located at the facility. The tanks, installed in 1942 and removed in 1989, were used to store heating oil until 1974, when they were converted to store waste POL. The leak, reported in 1981, was discovered in the southernmost UST. At that time it was estimated that the tank was releasing approximately 50 gallons of waste POL and solvents per month. It is not known how long the leak existed prior to its discovery. The tanks stopped receiving POL immediately upon discovery of the leak. The site was officially closed in April 1988, and the tanks were removed in June 1989. Soil samples taken during the excavation of the tanks had concentrations of total recoverable petroleum hydrocarbons (TRPH) of up to 14,000 milligrams per kilogram (mg/kg).

Since removal of the tanks, two additional potential sources of contamination have been discovered. During leak testing at the base, Tracer Research Corporation (TRC) injected a halon tracer into a pipeline that connects aboveground storage tanks (ASTs) located in the fuel yard just to the northeast of the pilot test site. Two leaks were discovered, one in an aboveground valve "Christmas tree" and another in the bottom of AST number 1054. The leaks were repaired in the spring and summer of 1992, respectively. Both the tree and the tank are still active. The leaks appear to be the primary source of a free-phase petroleum product plume beneath Site 27 (Radian Corporation, 1993a).

2.1.2 Site Geology

Because the bioventing technology is applied to the unsaturated soils, this section primarily addresses soils above the shallow aquifer. Nellis AFB is located in an area predominated by valley fill alluvium to depths of several thousand feet. The alluvium typically consists of silt, clay, fine sand, and some lenses of pebble conglomerate. Near-surface lithology at Site 27 consists of fine-grained sediments, with sands and clays being most common. Lenses of caliche are common throughout the entire soil profile.

The inferred potentiometric gradient suggests that groundwater flow direction is to the east on the northern portion of the site and gradually shifts to the southeast on the southern portion of the site. Groundwater occurs at depths ranging from 70 to 86 feet below ground surface (bgs). On the basis of groundwater level monitoring results from several sampling events, flow direction and gradient fluctuate slightly throughout the year (Radian Corporation, 1993a).

2.1.3 Site Contaminants

Since the removal of the USTs, extensive groundwater and soil sampling has been performed at the site by several consultants. A total of 45 groundwater monitoring wells have been installed in and around Site 27. Free product thickness of up to 8 feet was evident in 12 of the wells during sampling performed in December 1992 (Radian

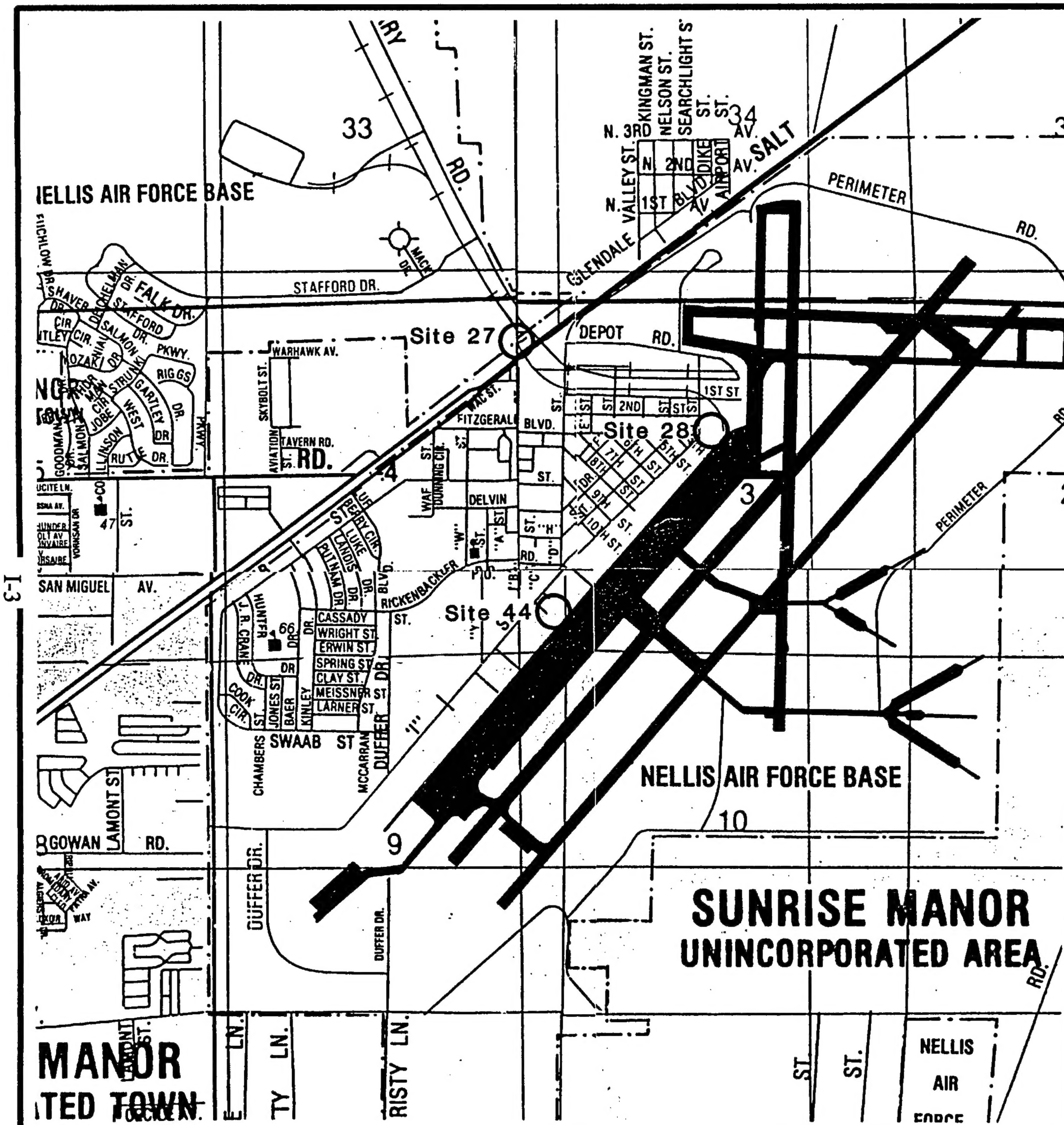

FIGURE 2.1

SITES 27, 28, AND 44
LOCATIONS IN RELATION
TO THE BASE

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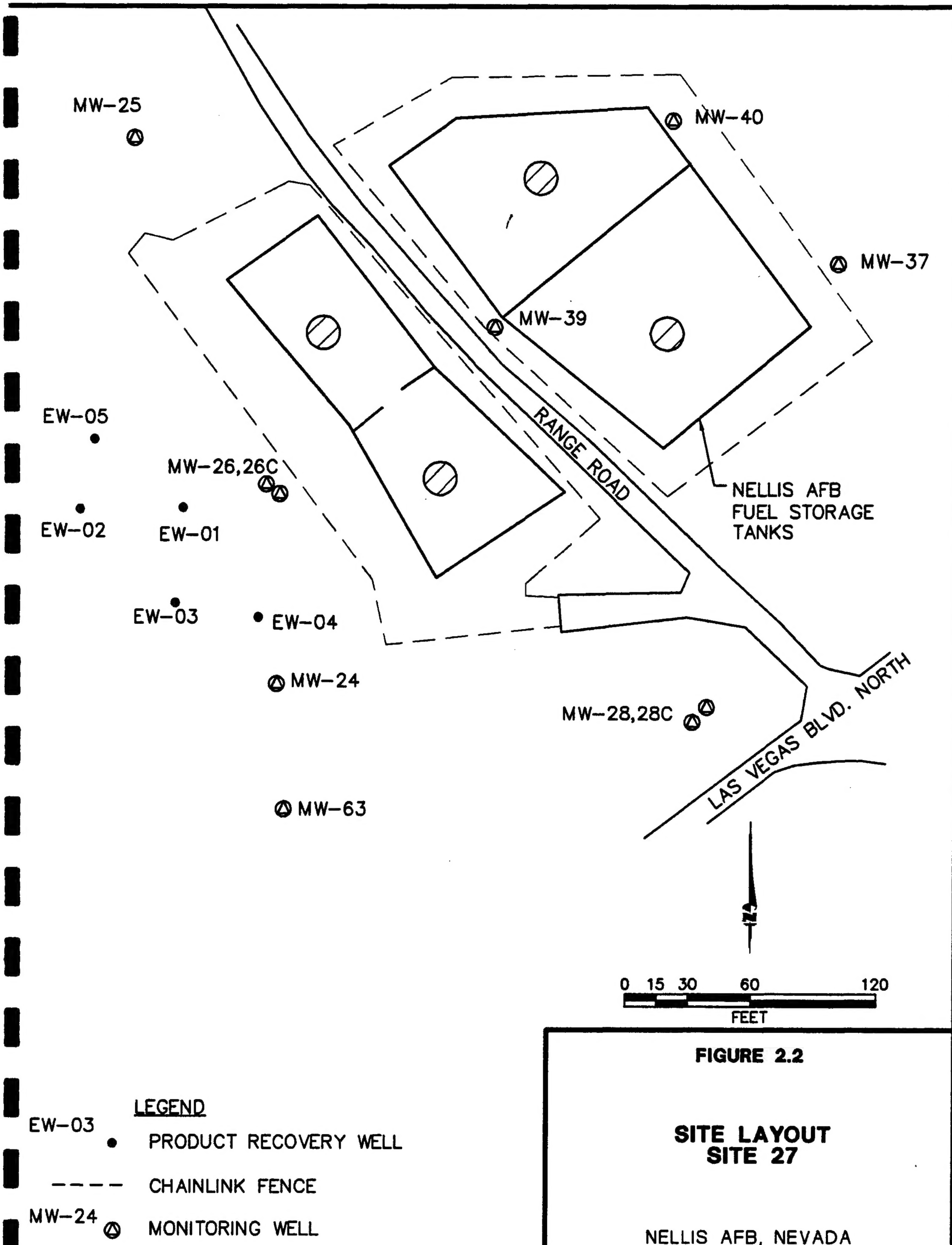

FIGURE 2.2

SITE LAYOUT
SITE 27

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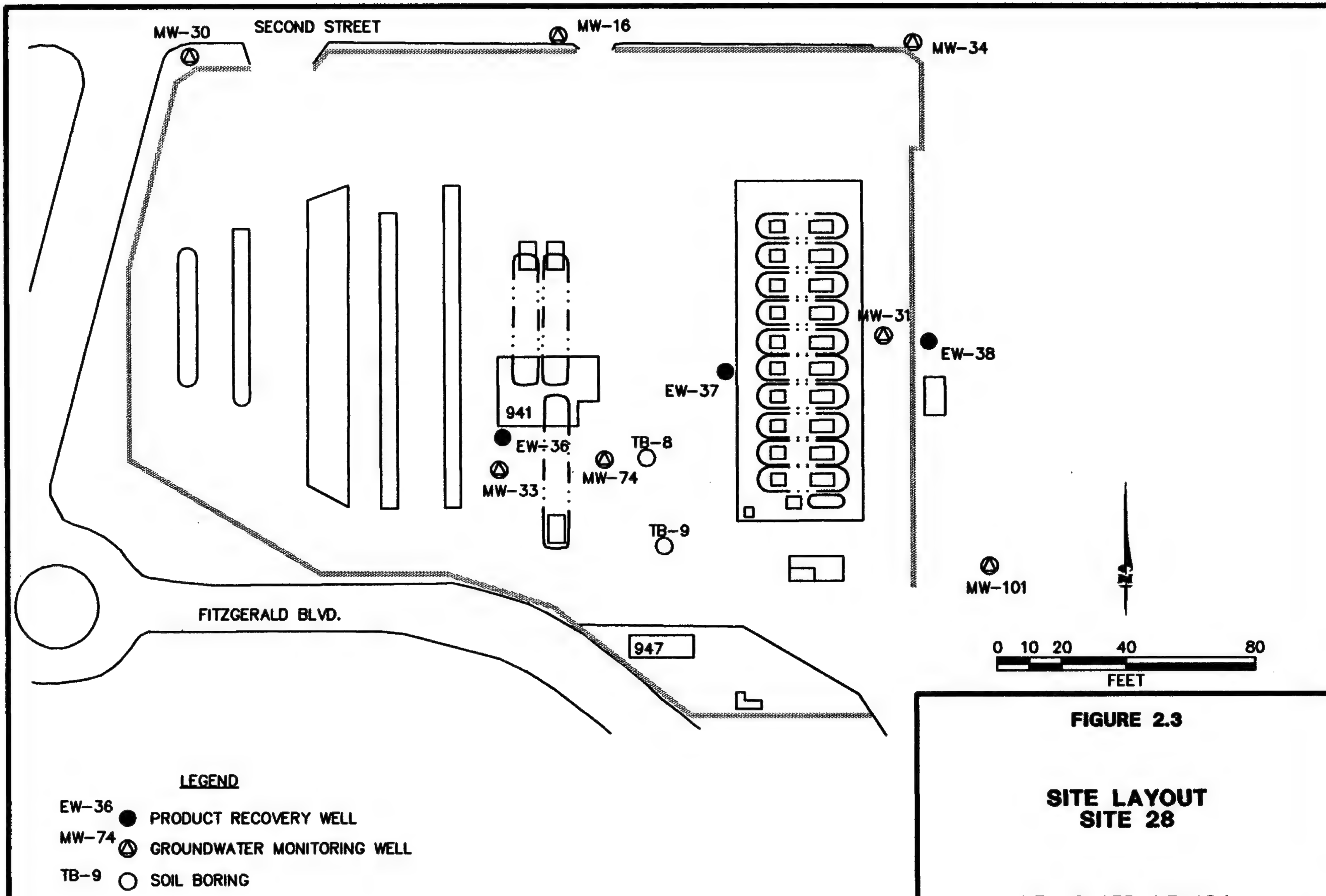

FIGURE 2.3

SITE LAYOUT
SITE 28

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nondetect levels to 11,000 µg/L at well MW-79, located on the apron to the east of the site (Radian Corporation, 1993b).

Soil headspace field screening and soil data collected during the installation of a monitoring well and two borings immediately to the north of the pilot test area suggest that contamination starts approximately 15 feet bgs and extends to the groundwater surface at approximately 50 feet bgs. Analytical soil samples contained TRPH concentrations of up to 24,000 mg/kg (Radian Corporation, 1993c).

2.3 Site 44

2.3.1 Site History and Location

Site 44 is the site of a petroleum hydrocarbon leak southwest of the aerospace ground equipment (AGE) shop. The AGE shop, Building 270, is located along the flight line off Tyndall Drive (Figures 2.1 and 2.4). A site investigation performed in October 1991 identified a plume of petroleum contamination extending southwest of Building 270. Three USTs were removed from a service island at the AGE shop in 1989 (Figure 2.4). At the time of the tank removal, a soil investigation was performed. Soil borings advanced to depths of 40 to 50 feet bgs in the vicinity of the tanks had elevated levels of TRPH (ES, 1993).

2.3.2 Site Geology

The geology of Site 44 is similar to that of Site 27 (Section 2.1.2), with slightly more sand in the sediment than Site 27. The inferred potentiometric gradient suggests that groundwater flow direction is to the east on the northwestern portion of the site and gradually shifts to the southeast on the southern and eastern portion of the site. Groundwater occurs at depths ranging from 32 to 35 feet below ground surface (bgs). On the basis of groundwater level monitoring results from several sampling events, flow direction and gradient fluctuate slightly throughout the year (ES, 1993).

2.3.3 Site Contaminants

Since the discovery of contamination at Site 44, extensive groundwater and soil monitoring has been performed at the site by a consultant. A total of 19 groundwater monitoring wells have been installed in and around Site 44. Free product has been observed in well MW-5 during recent sampling events. Sampling results from the site indicate that BTEX compounds are the primary contaminants at the site. BTEX concentrations in soil ranged from nondetect levels to 205 mg/kg at monitoring well MW-5. TRPH concentrations in samples taken from the borings ranged from 10 mg/kg to 5,400 mg/kg at MW-5. The majority of the contamination at MW-5 was found immediately below the former location of the AGE USTs at approximately 22 feet bgs (ES, 1992a and 1993).

3.0 PILOT TEST ACTIVITIES

The purpose of this section is to describe the pilot test activities to take place at Sites 27, 28, and 44. The proposed locations and construction details for the central VWs and vapor MPs are discussed. Criteria for locating a suitable background well position are outlined. Soil and soil gas sampling procedures and the blower configuration that will be used to

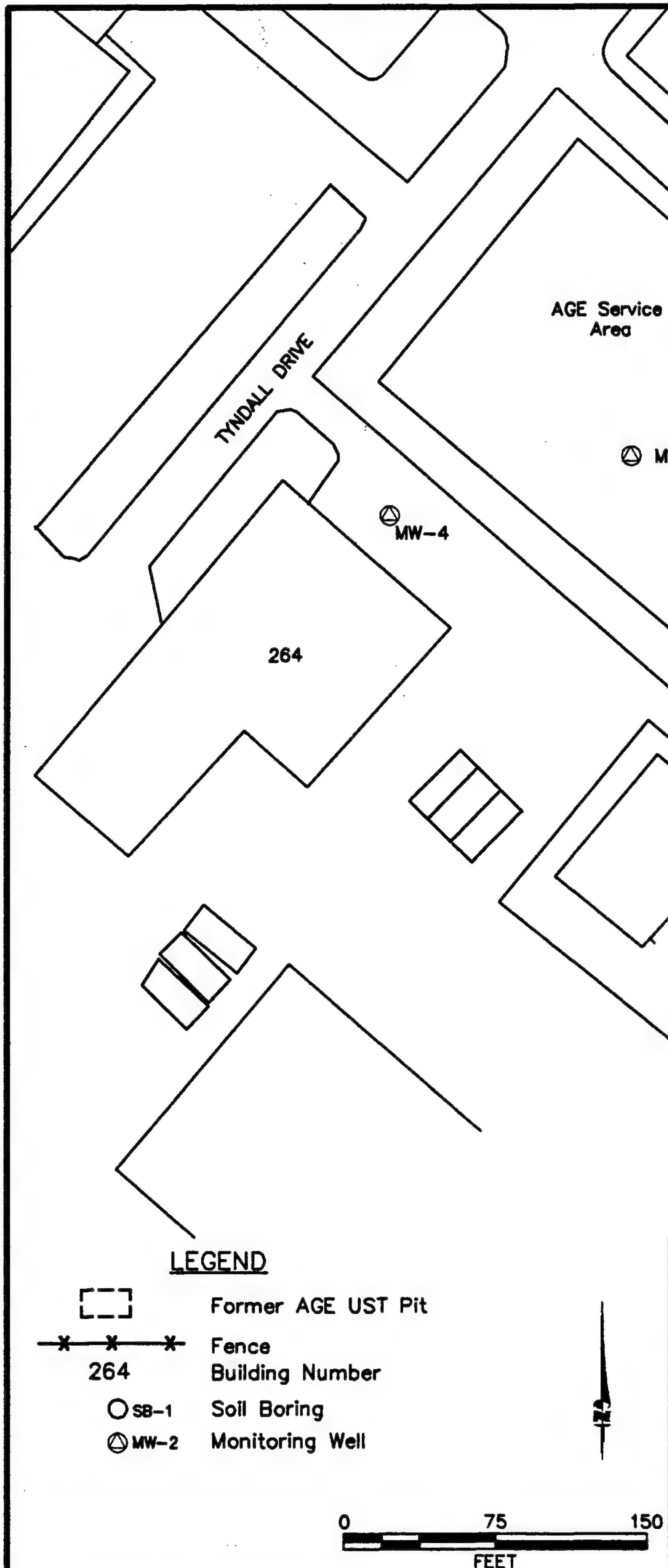

FIGURE 2.4

SITE LAYOUT
SITE 44

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Denver, Colorado

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inject air (oxygen) into contaminated soils are also discussed in this section. Finally, a brief description of the pilot test procedures is provided.

The bioventing technology is intended to remediate contamination only in the unsaturated zone. Therefore, pilot test activities will be confined mainly to unsaturated soils. The central VWs may be completed below the anticipated groundwater level. This is to provide oxygen to the deepest levels of the unsaturated zone in the event of natural groundwater table fluctuation and/or water table drawdown during future free product removal. No dewatering will take place during the pilot tests.

Existing monitoring wells will not be used as primary air injection wells. However, monitoring wells that have a portion of their screened interval above the water table may be used as vapor MPs or to measure the composition of background soil gas.

3.1 Bioventing Test Design for Site 27

A general description of criteria for siting a central VW and vapor MPs is included in the protocol document (Hinchee et al., 1992). Figure 3.1 illustrates the proposed locations of the central VW and MPs at Site 27. The final locations of these wells may vary slightly from the proposed locations if significant fuel contamination is not observed in the boring for the central VW. Soils in this area are expected to be contaminated with petroleum hydrocarbons and to be oxygen depleted (<2%). Biological activity should be stimulated by oxygen-rich soil gas ventilation during pilot test operations.

Due to the relatively deep contamination at this site and the potential for highly permeable soils, the potential radius of venting influence around the central VW is expected to be 40 to 50 feet. Three vapor MPs (MPA, MPB, and MPC) will be located within a 50-foot radius of the central VW.

The VW will be constructed of 4-inch-diameter Schedule 40 polyvinyl chloride (PVC) casing, with a 30-foot interval of 0.04-inch slotted screen set at 40 to 70 feet bgs. Flush-threaded PVC casing and screen with no organic solvents or glues will be used. The filter pack will be clean, well-rounded silica sand with a 6-9 grain size and will be placed in the annular space to 1 foot above the screened interval. A 35-foot layer of bentonite will be placed directly over the filter pack. The first 12 inches of bentonite will consist of bentonite pellets hydrated in place in 6-inch lifts with potable water. This layer of pellets will prevent the addition of bentonite slurry from saturating the filter pack. The remaining 34 feet of bentonite will be fully hydrated and mixed aboveground, and the slurry will be tremmied into the annular space to produce an air-tight seal above the screened interval. The borehole will then be completed to the ground surface with a bentonite/cement grout. A complete seal is critical to prevent injected air from short-circuiting to the surface during the bioventing test. Figure 3.2 illustrates the proposed central VW construction detail for this site.

A typical multidepth vapor MP installation for this site is shown in Figure 3.3. Soil gas oxygen and carbon dioxide concentrations will be monitored at depths of 40, 55, and 65 feet bgs at each location. Multidepth monitoring will confirm that the entire soil profile is receiving oxygen and will be used to measure fuel biodegradation rates at three depths. The annular spaces between the three screened MP intervals will be sealed with bentonite to isolate the monitoring intervals. As with the central VW, several inches of bentonite

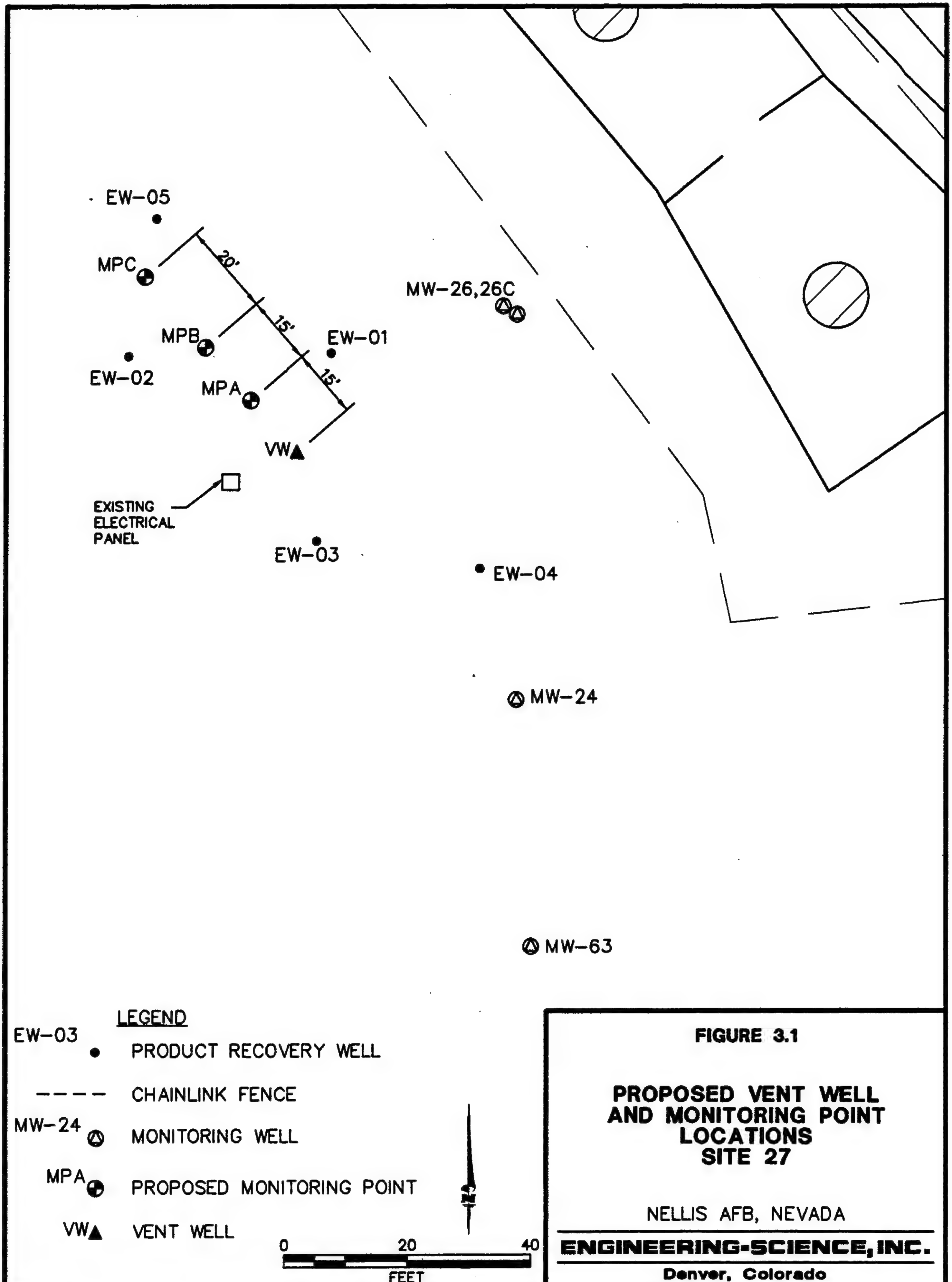

FIGURE 3.1

PROPOSED VENT WELL AND MONITORING POINT LOCATIONS SITE 27

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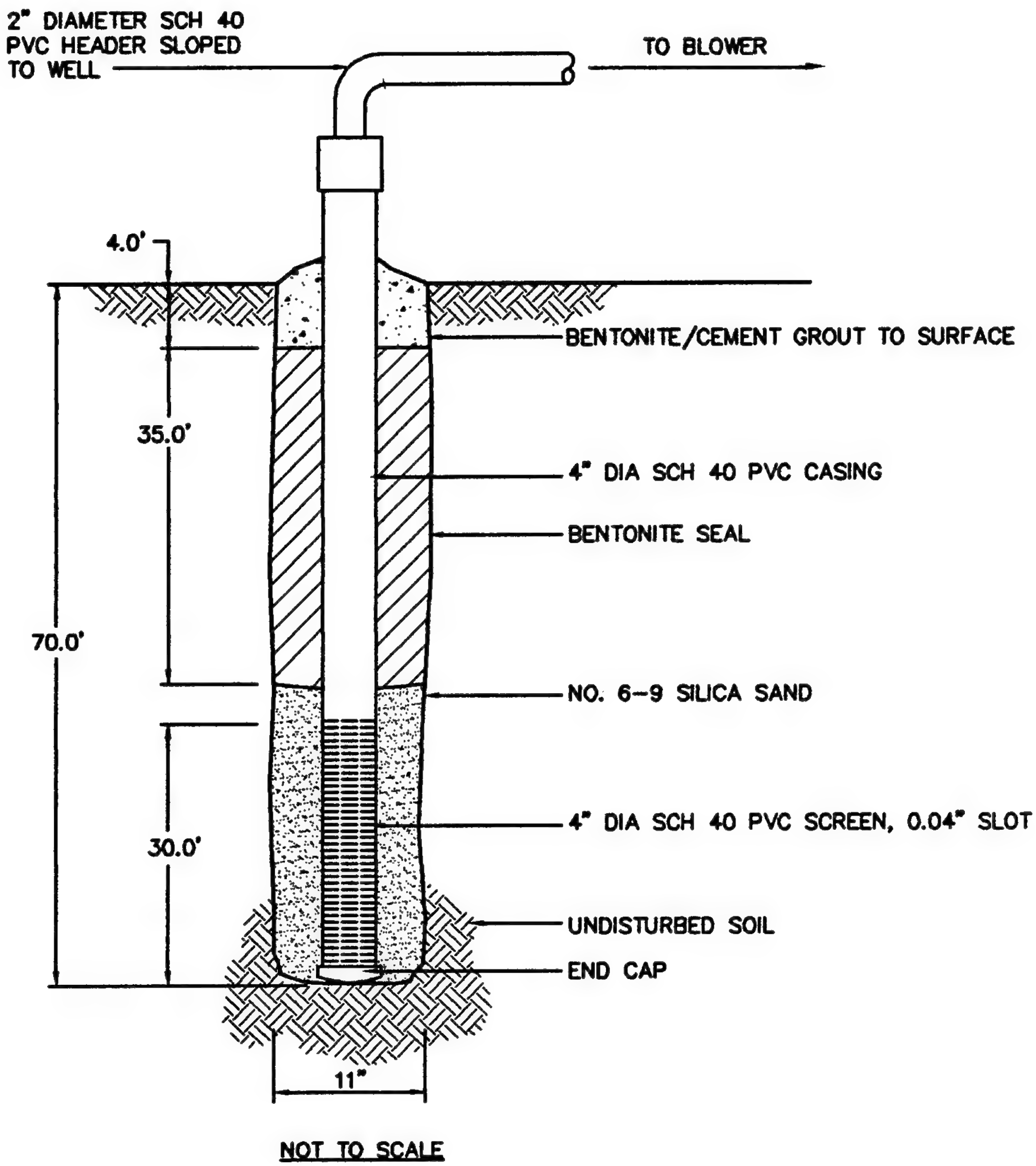

FIGURE 3.2

PROPOSED INJECTION VENT WELL CONSTRUCTION DETAIL SITE 27

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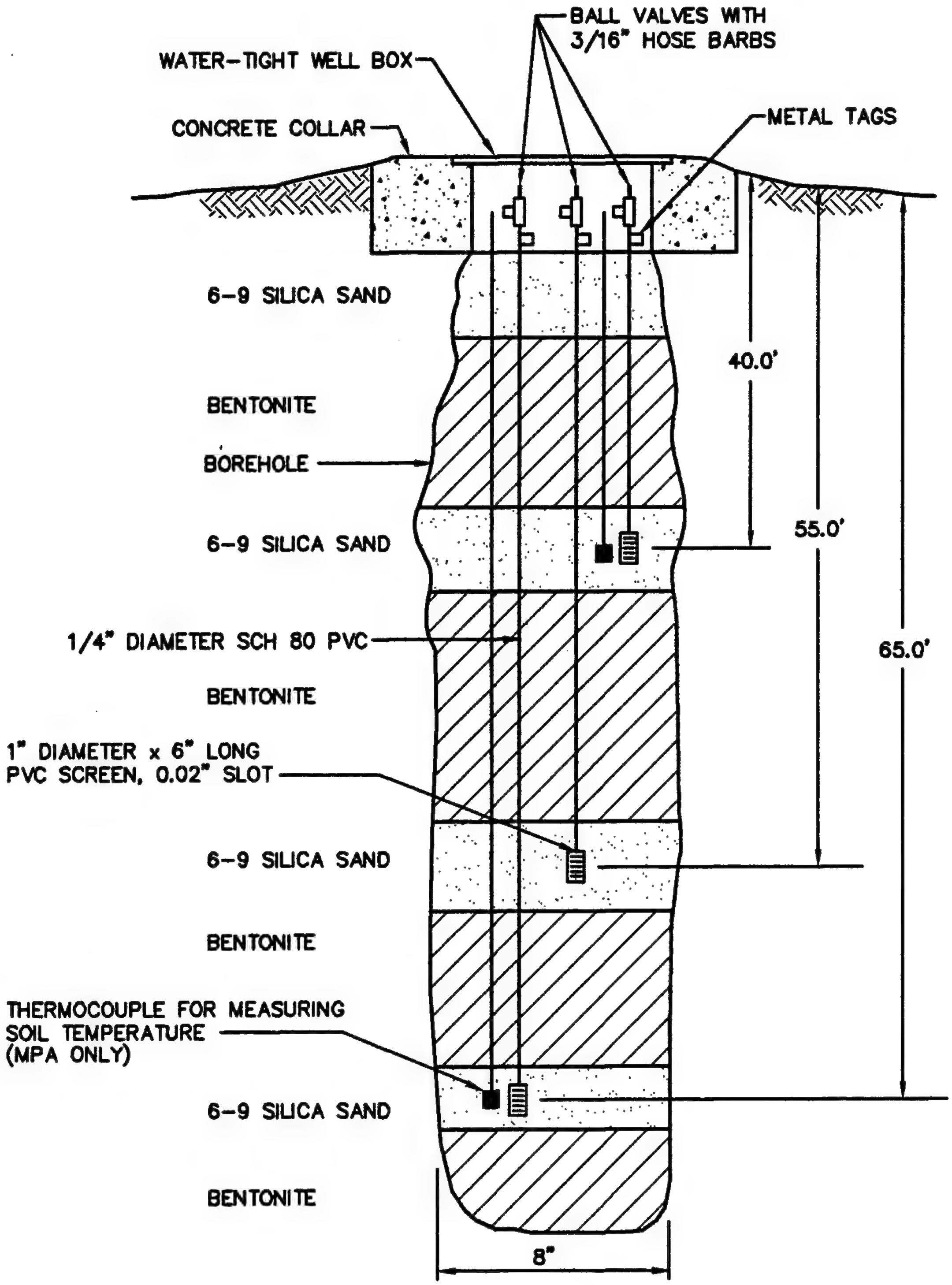

NOT TO SCALE

FIGURE 3.3

PROPOSED TYPICAL MONITORING POINT CONSTRUCTION DETAIL SITE 27

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Denver, Colorado

pellets will be used to shield the filter pack from rapid infiltration of bentonite slurry additions. Thermocouples will be installed at the shallowest and deepest depths at MPA to measure soil temperature. Additional details on VW and MP construction are presented in Section 4 of the protocol document (Hinchee et al., 1992).

3.2 Bioventing Test Design for Site 28

Figure 3.4 illustrates the proposed locations of the central VW and MPs at Site 28. The final location of these wells may vary slightly from the proposed location if significant fuel contamination is not observed in the boring for the central VW. Soils in this area are expected to be contaminated with petroleum hydrocarbons and to be oxygen depleted (<2%). Biological activity should be stimulated by oxygen-rich soil gas ventilation during pilot test operations.

Due to the relatively deep contamination at this site and the potential for highly permeable soils, the potential radius of venting influence around the central VW is expected to be 50 to 60 feet. Three vapor MPs (MPA, MPB, and MPC) will be located within a 60-foot radius of the central VW.

The VW will be constructed of 4-inch-diameter Schedule 40 PVC, with a 35-foot interval of 0.04-inch slotted screen set at 15 to 50 feet bgs. Flush-threaded PVC casing and screen with no organic solvents or glues will be used. The filter pack will be clean, well-rounded silica sand with a 6-9 grain size and will be placed in the annular space to 1 foot above the screened interval. A 12-foot layer of bentonite will be placed directly over the filter pack. The first 12 inches of bentonite will consist of bentonite pellets hydrated in place in 6-inch lifts with potable water. This layer of pellets will prevent the rapid addition of bentonite slurry from saturating the upper portion of the filter pack. The remaining 11 feet of bentonite will be fully hydrated and mixed aboveground, and then tremmied into the annular space to produce an air-tight seal above the screened interval that will prevent injected air from short-circuiting to the surface during the bioventing test. The well will be completed to the ground surface with a bentonite/cement grout. Figure 3.5 illustrates the proposed central VW construction for this site.

A typical multidepth vapor MP installation design for this site is shown in Figure 3.6. Soil gas oxygen and carbon dioxide concentrations will be monitored at depths of 20, 32, and 45 feet bgs at each location. Multidepth monitoring will confirm that the entire soil profile is receiving oxygen, and will be used to measure fuel biodegradation rates at each depth. The annular spaces between the three monitoring intervals in each MP will be sealed with bentonite to isolate the intervals. As in the central VW, several inches of bentonite pellets will be used to shield the filter pack from rapid infiltration of bentonite slurry additions. Thermocouples will be installed at the shallowest and deepest depths at MPA to measure soil temperature. Additional details on VW and MP construction are provided in Section 4 of the protocol document (Hinchee et al., 1992).

3.3 Bioventing Test Design for Site 44

Figure 3.7 illustrates the proposed locations of the central VW and MPs at Site 44. The final location of these wells may vary slightly from the proposed location if significant fuel contamination is not observed in the boring for the central VW. Soils in this area are expected to be contaminated with petroleum hydrocarbons and to be oxygen depleted

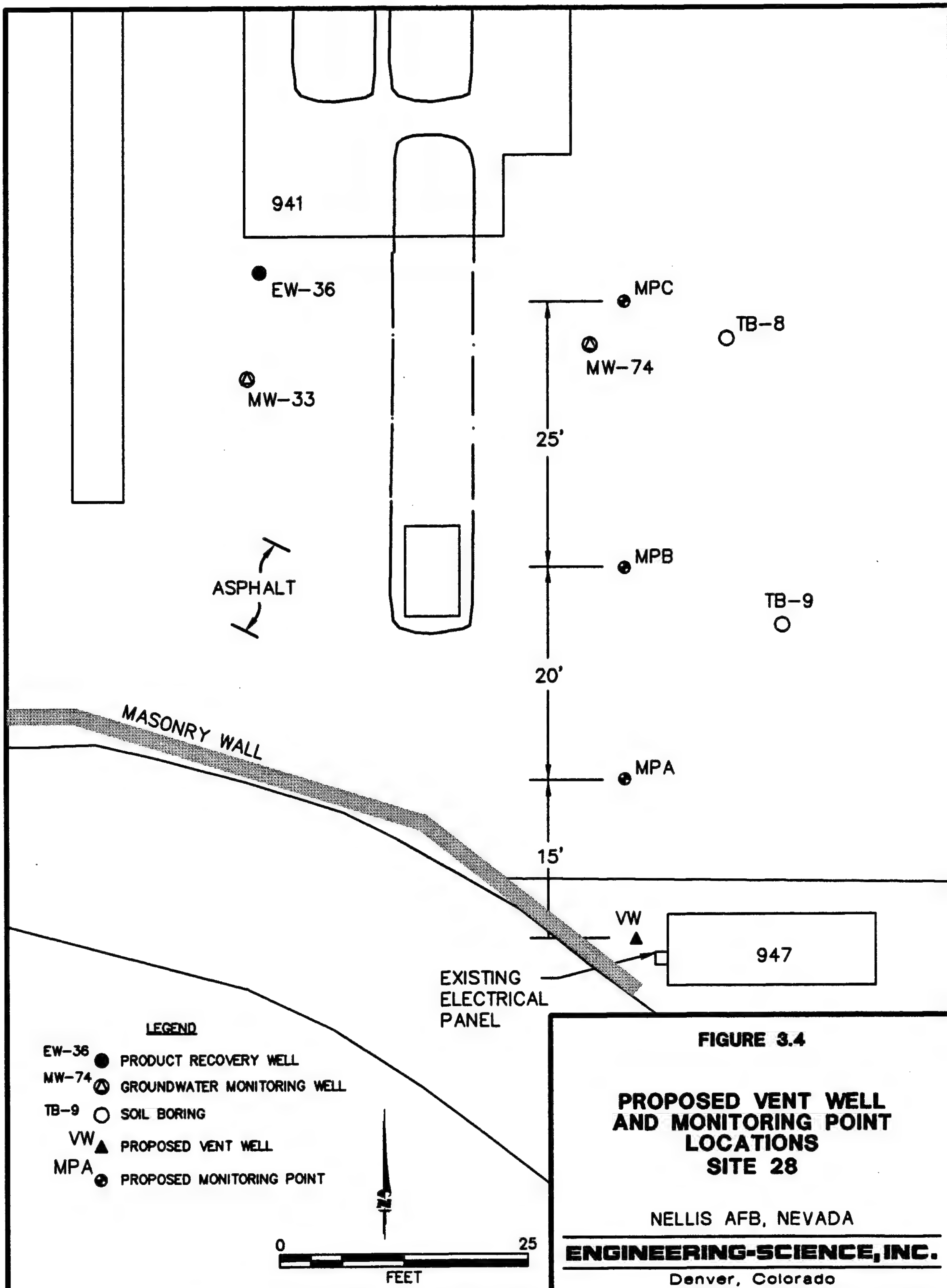

FIGURE 3.4

PROPOSED VENT WELL AND MONITORING POINT LOCATIONS SITE 28

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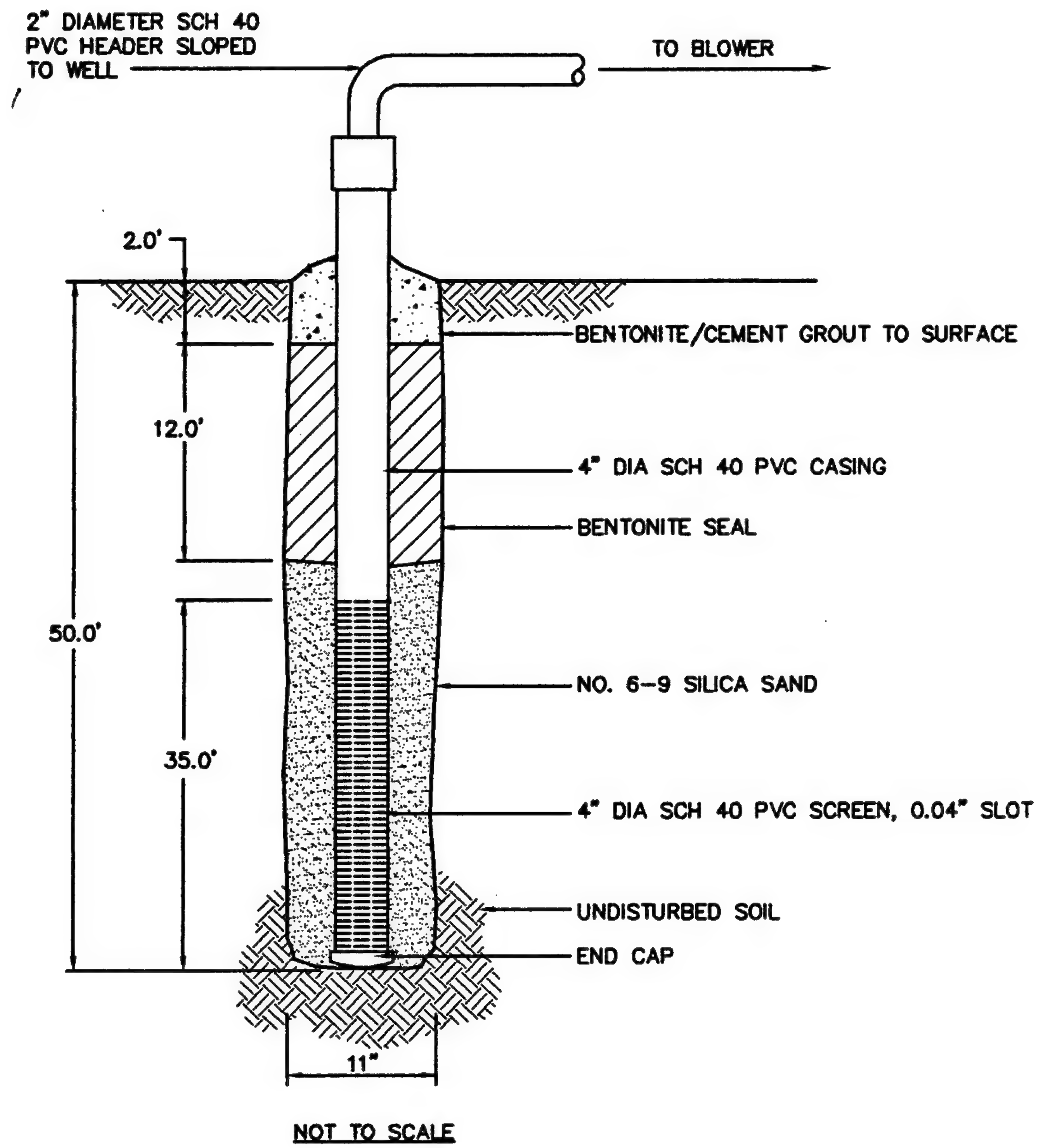

FIGURE 3.5

PROPOSED INJECTION VENT WELL CONSTRUCTION DETAIL SITE 28

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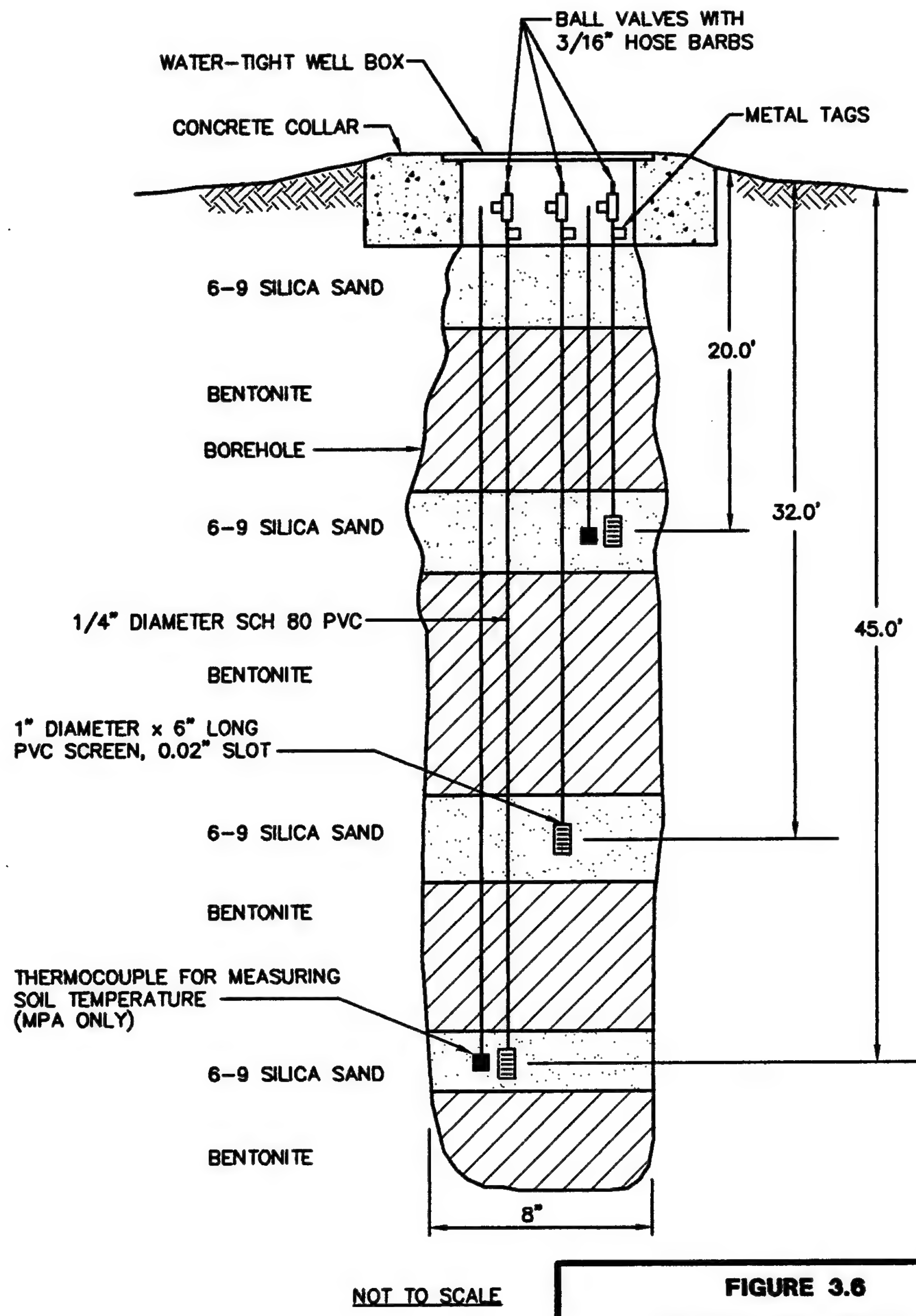

FIGURE 3.6

PROPOSED TYPICAL MONITORING POINT CONSTRUCTION DETAIL SITE 28

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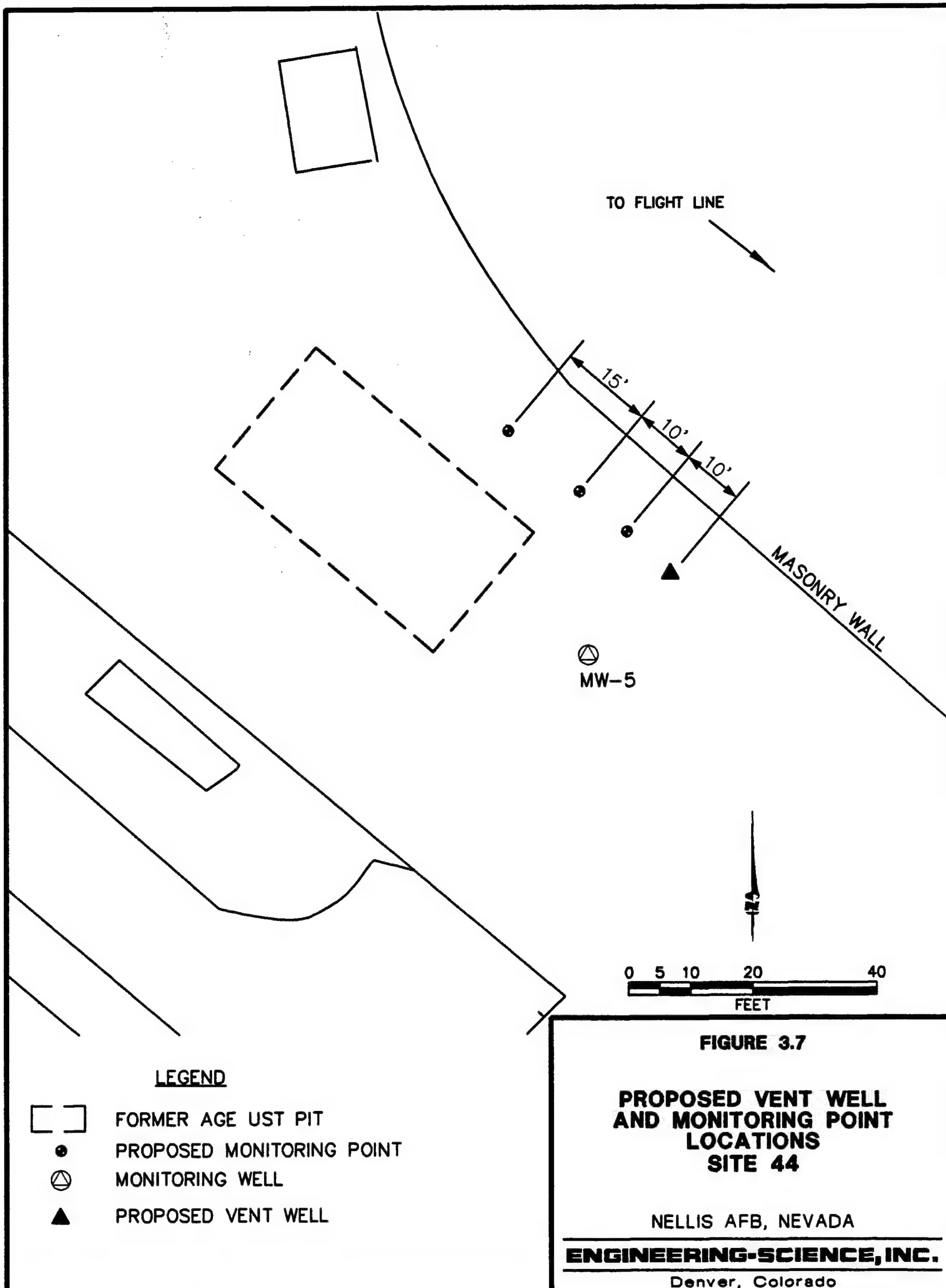

FIGURE 3.7

PROPOSED VENT WELL AND MONITORING POINT LOCATIONS SITE 44

NELLIS AFB, NEVADA

ENGINEERING-SCIENCE, INC.

Denver, Colorado

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(<2%). Biological activity should be stimulated by oxygen-rich soil gas ventilation during pilot test operations.

Due to the shallower depth of contamination at this site and the potential for highly permeable soils, the potential radius of venting influence around the central VW is expected to be 25 to 35 feet. Three vapor MPs (MPA, MPB, and MPC) will be located within a 35-foot radius of the central VW.

The VW will be constructed of 4-inch-diameter Schedule 40 PVC, with a 15-foot interval of 0.04-inch slotted screen set at 18 to 43 feet bgs. Flush-threaded PVC casing and screen with no organic solvents or glues will be used. The filter pack will be clean, well-rounded silica sand with a 6-9 grain size and will be placed in the annular space to one foot above the screened interval. A 15-foot layer of bentonite will be placed directly over the filter pack. The first 12 inches of bentonite will consist of bentonite pellets hydrated in place in 6-inch lifts with potable water. This layer of pellets will prevent the rapid addition of bentonite slurry from saturating the upper portion of the filter pack. The remaining 14 feet of bentonite will be fully hydrated and mixed aboveground, and then tremmied into the annular space to produce an air-tight seal above the screened interval that will prevent injected air from short-circuiting to the surface during the bioventing test. The well will be completed to the ground surface with a bentonite/cement grout. Figure 3.8 illustrates the proposed central VW construction for this site.

A typical multi-depth vapor MP installation design for this site is shown in Figure 3.9. Soil gas oxygen and carbon dioxide concentrations will be monitored at depths of 20, 30, and 40-feet bgs at each location. Multi-depth monitoring will confirm that the entire soil profile is receiving oxygen, and will be used to measure fuel biodegradation rates at each depth. The annular spaces between the three monitoring intervals in each MP will be sealed with bentonite to isolate the intervals. As in the central VW, several inches of bentonite pellets will be used to shield the filter pack from rapid infiltration of bentonite slurry additions. Thermocouples will be installed at the shallowest and deepest depths at MPA to measure soil temperature. Additional details on VW and MP construction are provided in Section 4 of the protocol document (Hinchee et al., 1992).

3.4 Background Well

The construction of an additional vapor MP may be required to measure background levels of oxygen and carbon dioxide and to determine if natural carbon sources are contributing to oxygen uptake during the *in situ* respiration test described in Section 3.7. This background well would be installed in an area of uncontaminated soil and in the same stratigraphic formation as the VWs and MPs to be installed at Sites 27, 28, and 44. The background well would be similar in construction to the MPs (Figures 3.3, 3.6, and 3.9), and would be screened at three depths. ES will require assistance from Nellis AFB in selecting an appropriate location for the proposed background well.

3.5 Handling of Drill Cuttings

Drill cuttings from all VW and MP borings will be collected in US Department of Transportation (DOT) approved containers. The containers will be labeled and placed in the Nellis AFB hazardous materials storage area. These drill cuttings will become the responsibility of Nellis AFB, and will be analyzed, handled, and disposed of in accordance

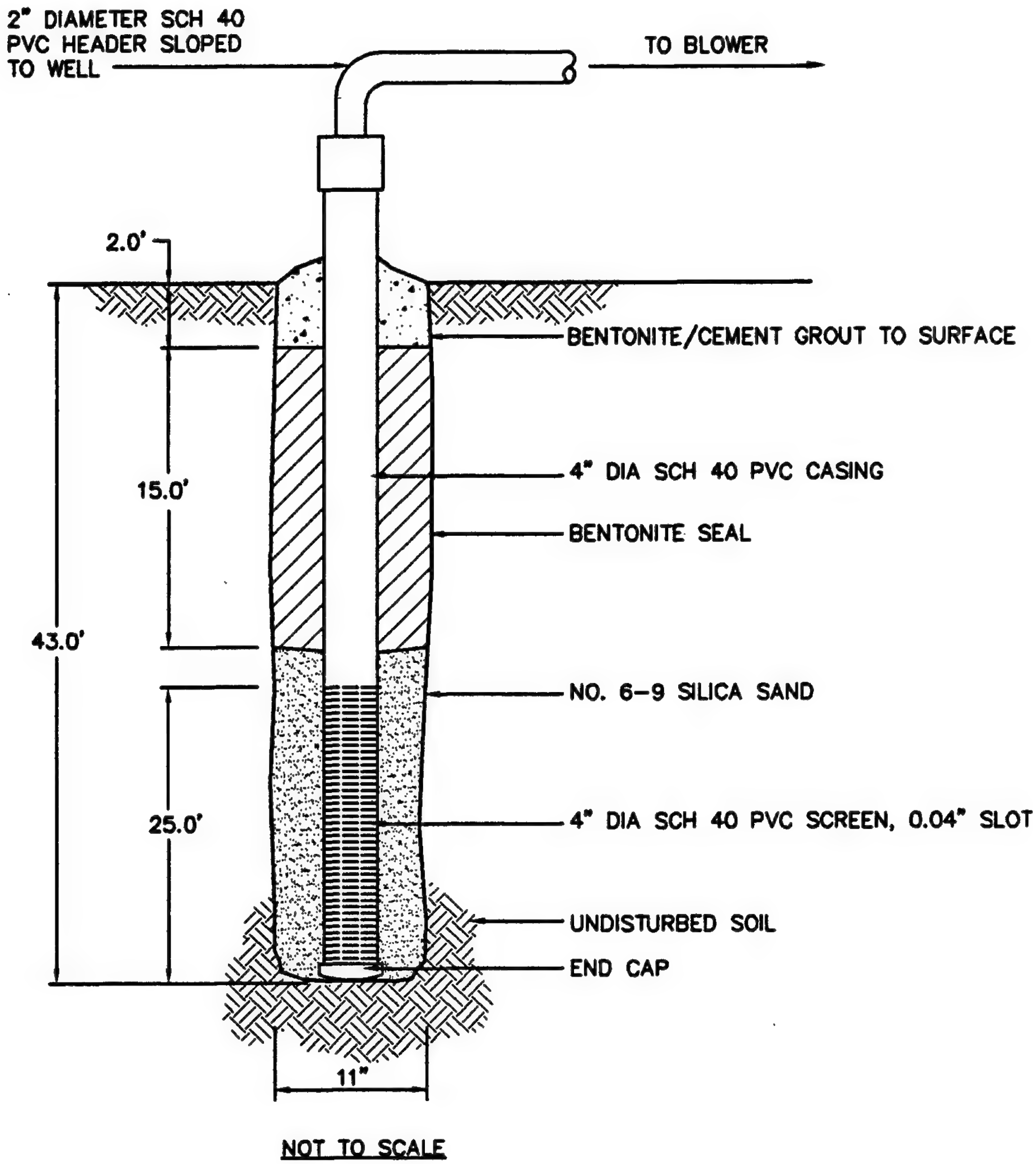

FIGURE 3.8

PROPOSED INJECTION VENT WELL CONSTRUCTION DETAIL SITE 44

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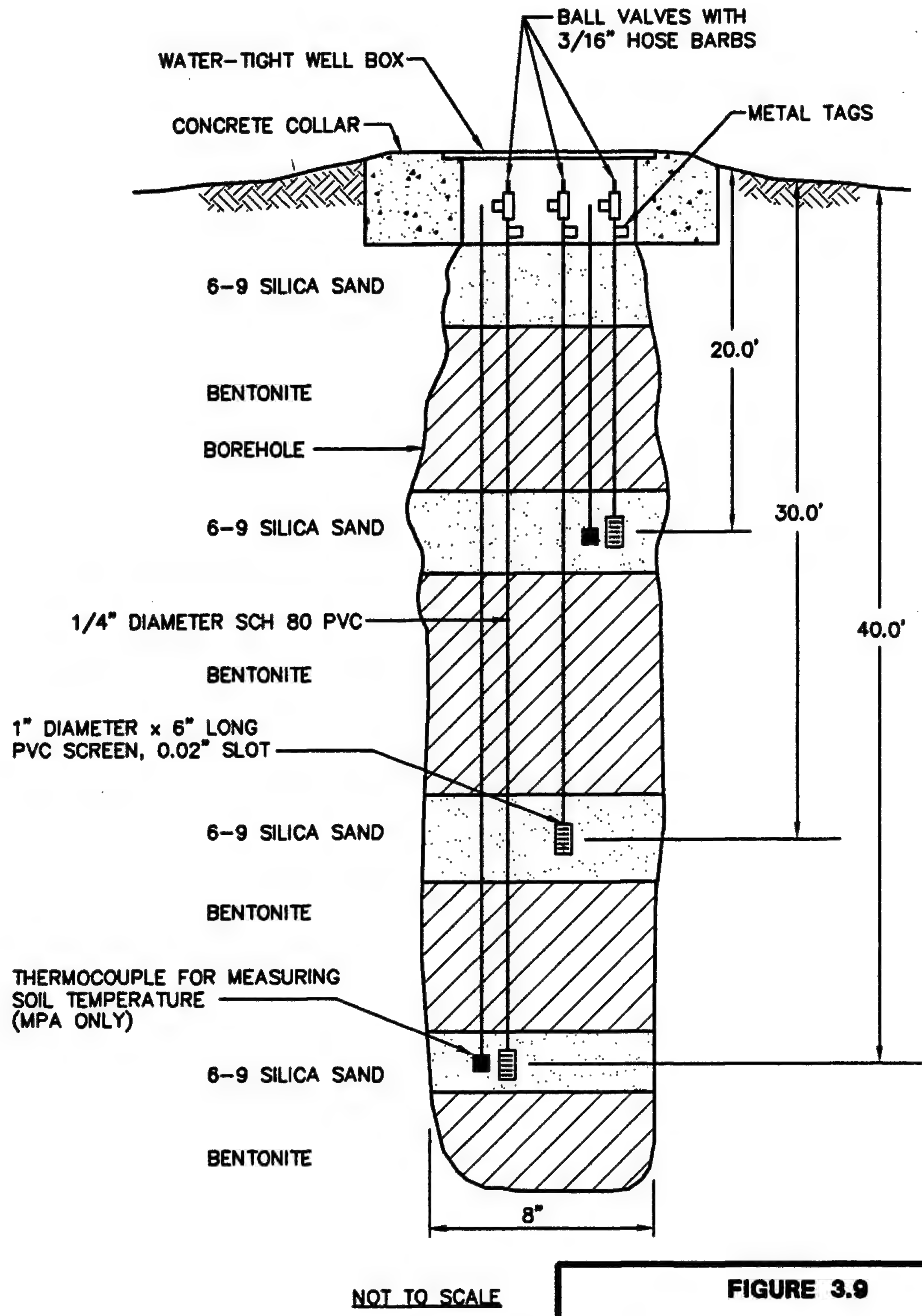

FIGURE 3.9

PROPOSED TYPICAL MONITORING POINT CONSTRUCTION DETAIL SITE 44

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with the current procedures for ongoing remedial investigations. This project is expected to generate approximately 20 55-gallon drums of cuttings.

3.6 Soil and Soil Gas Sampling

3.6.1 Soil Samples

Three soil samples will be collected from each pilot test area during the installation of the VW and MPs. Sampling procedures will follow those outlined in the protocol document. One sample will be collected from the most contaminated interval of each VW boring, and one sample will be collected from the interval of highest apparent contamination in each of the borings for the two MPs closest to the VW. Soil samples will be analyzed for TRPH, BTEX, soil moisture, pH, particle sizing, alkalinity, total iron, and nutrients. One sample will be collected from the background MP boring and analyzed for total Kjeldahl nitrogen (TKN).

Samples for TRPH and BTEX analysis will be collected using a split-spoon sampler containing brass tube liners. Soil samples collected in the brass tubes for TRPH and BTEX analyses will be immediately trimmed, and the ends will be sealed with aluminum foil or Teflon® fabric held in place by plastic caps. Soil samples collected for physical parameter analyses will be placed in glass sample jars or other appropriate sample containers specified in the base sample handling plan. Soil samples will be labeled following the nomenclature specified in the protocol document (Section 5), wrapped in plastic, and placed in a cooler for shipment. A chain-of-custody form will be filled out, and the cooler will be shipped to the Pace, Inc. laboratory in Huntington Beach, California, for analysis. This laboratory has been audited by the Air Force and meets all quality assurance/quality control and certification requirements for the State of California.

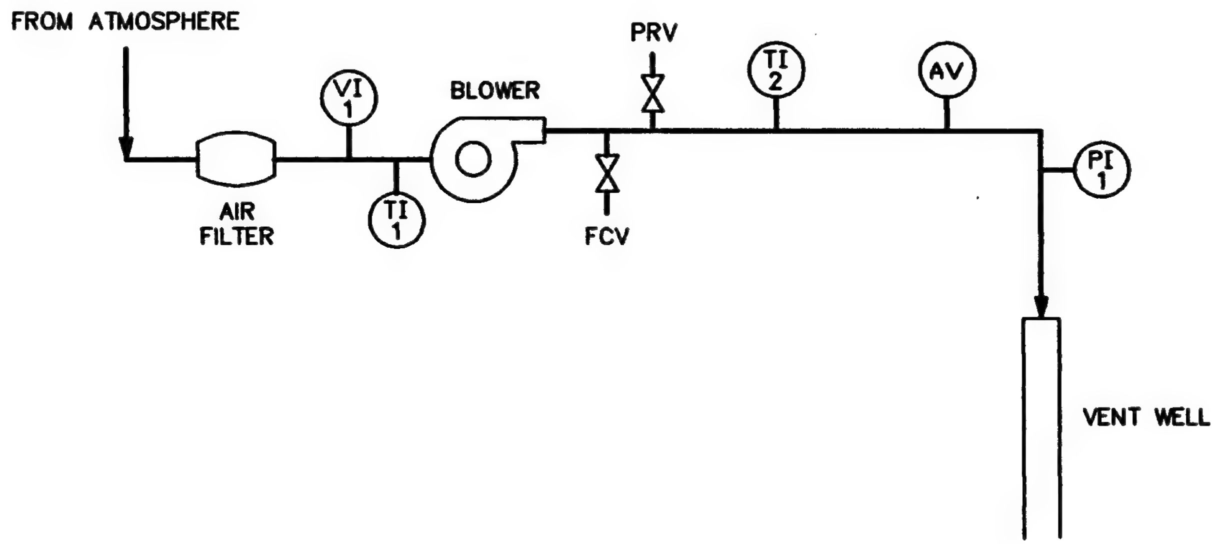
3.6.2 Soil Gas Samples

A total hydrocarbon vapor analyzer will be used during auguring to screen split-spoon soil samples for intervals of fuel contamination. Initial and final soil gas samples will be collected in SUMMA® canisters, in accordance with the bioventing field sampling plan (ES, 1992b), from the VWs and from the MPs closest to and furthest from the VWs. Additionally, these soil gas samples will be used to predict potential air emissions, to determine the reduction in BTEX and total volatile hydrocarbons (TVH) during the 1-year test, and to detect any migration of these vapors from the source area.

Soil gas sample canisters will be placed in a small cooler and packed with foam pellets to prevent excessive movement during shipment. Samples will not be sent on ice in order to prevent condensation of hydrocarbons. A chain-of-custody form will be filled out, and the cooler will be shipped to the Air Toxics, Inc. laboratory in Folsom, California for analysis.

3.7 Blower Systems

A 3-horsepower positive-displacement blower capable of injecting air at a flow rate of 20 to 40 standard cubic feet per minute (scfm) at a pressure of 8 pounds per square inch (psi) will be used to conduct the initial air permeability tests at each site. Figure 3.10 is a schematic of a typical air injection system used for pilot testing. The maximum power requirement anticipated for these pilot tests is 230-volt, single-phase, 30-amp service. Additional



LEGEND

- VI 1 — VACUUM INDICATOR
- PI 1 — PRESSURE INDICATOR
- TI 1 — TEMPERATURE INDICATOR
- AV — AIR VELOCITY INDICATOR
- FCV — FLOW CONTROL VALVE
- PRV — PRESSURE RELIEF VALVE

FIGURE 3.10

PROPOSED BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION

NELLIS AFB, NEVADA

ENGINEERING-SCIENCE, INC.

Denver, Colorado

93DN1320, 11/23/93 at 14:51

details on power supply requirements are described in Section 5.0, Base Support Requirements.

3.8 *In Situ* Respiration Tests

The objective of the *in situ* respiration tests is to determine the rate at which soil bacteria degrade petroleum hydrocarbons. Respiration tests will be performed at every vapor MP at each of the three sites where bacterial biodegradation of hydrocarbons is indicated by low oxygen levels and elevated carbon dioxide concentrations in the soil gas. Using a 1-scfm pump, air will be injected into each MP depth interval containing low levels (<2%) of oxygen. A 20-hour air injection period will be used to oxygenate local contaminated soils. At the end of the 20-hour air injection period, the air supply will be cut off, and oxygen and carbon dioxide levels will be monitored for the following 48 to 72 hours. The decline in oxygen and increase in carbon dioxide concentrations over time will be used to estimate rates of bacterial degradation of fuel residuals. Helium will also be injected at three or four MPs at each site to determine whether there are leaks in the monitoring points, allowing oxygen to escape. Additional details on the *in situ* respiration test procedures are provided in Section 5.7 of the protocol document (Hinchee et al., 1992).

3.9 Air Permeability Tests

The objective of the air permeability tests is to determine the extent of the subsurface that can be oxygenated using the VWs. Air will be injected into the 4-inch-diameter VWs using the blower unit, and pressure response will be measured at each MP with differential pressure gauges to determine the region influenced by the unit. Oxygen will also be monitored in the MPs to ascertain whether oxygen levels in the soil increase as the result of air injection. One air permeability test lasting 4 to 8 hours will be performed at each site.

3.10 Potential for Air Emissions

The potential for air emissions is considered low for these sites. Soil gas will move outward and upward from the deep contamination, and volatile contaminants in the soil gas will biodegrade as the gas migrates. During initial air injection, health and safety monitoring will ensure that breathing-zone hydrocarbon concentrations do not exceed 1 part per million, volume per volume (ppmv).

3.11 Extended Pilot Test Bioventing System

If initial testing shows adequate soil permeability and oxygen transport, extended bioventing systems will also be installed at Site 27, 28, and 44. At each site, the base will be requested to provide a power pole with a 230-volt, single-phase, 30-amp breaker box, one 230-volt receptacle, and one 110-volt duplex receptacle. Depending on the availability of a base electrician, a base electrician or a licensed electrician subcontracted to ES will assist in wiring the blowers to line power. The blowers will be 1.0-horsepower regenerative blowers capable of injecting air at approximately 2 psi and 88 scfm. The blowers will be provided with vacuum, pressure, and temperature gauges, air filters, and pressure relief and flow control valves (see Figure 3.10). The blowers will be housed in small, prefabricated sheds to provide protection from the weather.

The systems will be in operation for 1 year, and every 6 months ES personnel will conduct *in situ* respiration tests to monitor the long-term performance of this bioventing system. Weekly system checks will be performed by Nellis AFB personnel. If required, major maintenance of the blower unit may be performed by ES personnel. Detailed blower system information and a maintenance schedule will be included in the operation and maintenance (O&M) manual to be provided to the base. More detailed information regarding the test procedures can be found in the protocol document.

4.0 EXCEPTIONS TO PROTOCOL PROCEDURES

The procedures that will be used to measure the air permeability of the soil and *in situ* respiration rates are described in Sections 4 and 5 of the protocol document (Hinchee et al., 1992). No exceptions to the protocol procedures are anticipated.

5.0 BASE SUPPORT REQUIREMENTS

The following base support is needed prior to the arrival of the drilling subcontractor and the ES pilot test team:

- Assistance in obtaining drilling and digging permits.
- Assistance in selecting a suitable location for the background well. The background well location should be in an area with no fuel contamination and with similar stratigraphy to that of Sites 27, 28, and 44. Preferably, a 110-volt receptacle will be available within 150 feet of the background well location.
- Installation of power at Sites 27, 28, 44. Each site will require a 230-volt, 30-amp, single-phase service and a breaker box with one 230-volt receptacle and one 110-volt duplex receptacle. The breaker box should be located as close as possible, but within 50 feet of the proposed central VW location at each site.
- Provision of any paperwork required to obtain gate passes and security badges for approximately two ES employees, two drillers, and an electrician (if a base electrician is not available). Vehicle passes will be needed for one truck and a drill rig.

During the initial testing, the following base support is needed:

- A decontamination area where the driller can clean augers between borings.
- Acceptance of responsibility by Nellis AFB for drill cuttings from VW and MP borings, including any sampling to determine hazardous waste status.
- Twelve square feet of desk space and a telephone in a building located as close to the site as practicable.
- The use of a facsimile machine for transmitting 15 to 20 pages of test results.

During the 1-year extended pilot test, base personnel will be required to perform the following activities:

- Check the blower system once per week to ensure that it is operating and to record the air injection pressure and temperature. Change air filters when required. ES will provide a brief training session on these procedures and an O&M manual.

- If the blower stops working, notify Mr. Russell Frishmuth or Mr. Doug Downey, ES-Denver, at (303) 831-8100, or Mr. Marty Faile, AFCEE, at (210) 536-4342.
- Arrange site access for an ES technician to conduct *in situ* respiration tests approximately 6 months and 1 year after the initial pilot test.

6.0 PROJECT SCHEDULE

The following schedule is contingent upon timely approval of this pilot test work plan.

Event	Date
Draft Test Work Plan to AFCEE/Nellis AFB	9 December 1993
Begin Initial Pilot Tests	11 January 1994

Event	Date
Complete Initial Pilot Tests	10 February 1994
Interim Results Report	30 March 1994
Second Respiration Tests	August 1994
Final Respiration Tests	February 1995

7.0 POINTS OF CONTACT

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4551 Devlin Drive
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(702) 652-3164

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USAFWTC/EVR
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(707) 652-3567

Marty Faile
AFCEE/EST
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Brooks AFB, TX 78235-5103
(210) 536-4366

Doug Downey and
Russell Frishmuth
Engineering-Science, Inc.
1700 Broadway, Suite 900
Denver, CO. 80290
(303) 831-8100
Fax (303) 831-8208

8.0 REFERENCES

Engineering-Science, Inc. (ES). 1992a. *Service Island Site Assessment, Nellis Air Force Base, Las Vegas, Nevada.* March. Austin, TX.

Engineering-Science, Inc. (ES). 1992b. *Field Sampling Plan for AFCEE Bioventing.* April. Denver, CO.

Engineering-Science, Inc. (ES). 1993. *Remedial Investigation of Site 44 at Nellis Air Force Base, Las Vegas, Nevada.* Interim Draft. August. Houston, TX.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing.* January.

OHM Remediation Services Corporation. 1992. *Site 27 Fuel Recovery System Installation, Nellis Air Force Base, Las Vegas, Nevada.* Volume I. December. Walnut Creek, CA.

Radian Corporation. 1993a. *December 1992 Quarterly Monitoring Report Site 27, Nellis Air Force Base, Nevada.* April. Austin, TX.

Radian Corporation. 1993b. *March 1993 Quarterly Monitoring Report Site 28, Nellis Air Force Base, Nevada.* June. Austin, TX.

Radian Corporation. 1993c. *Installation Restoration Program Remedial Investigation for Sites 27 and 28. Technical Memorandum, Nellis Air Force Base, Nevada.* Draft. January. Austin, TX.

PART II

DRAFT INTERIM PILOT TEST RESULTS REPORT FOR SITES 27, 28, AND 44

NELLIS AFB, NEVADA

March 1994

Prepared for:

Air Force Center for Environmental Excellence
Brooks AFB, Texas

and

USAFWTC/EVR
Nellis AFB, Nevada

Prepared by:

Engineering-Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado 80290

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PART II - DRAFT INTERIM PILOT TEST RESULTS REPORT FOR SITES 27, 28, AND 44 NELLIS AFB, NEVADA

CONTENTS (Continued)

TABLES

FIGURES

FIGURES (Continued)

PART II

DRAFT
INTERIM PILOT TEST RESULTS REPORT FOR SITES 27, 28, AND 44 NELLIS AFB, NEVADA

Initial bioventing pilot tests for *in situ* treatment of fuel-contaminated soils at Sites 27, 28, and 44 at Nellis Air Force Base (AFB) (the Base), Nevada were completed by Engineering-Science, Inc. (ES) during the period from January 11 through February 10, 1994. The three primary objectives of the pilot tests are:

- To assess the potential for supplying oxygen throughout the contaminated soil interval;
- To determine the rate at which indigenous microorganisms will degrade fuel when supplied with oxygen-rich soil gas, and
- To evaluate the potential for sustaining these rates of biodegradation until fuel contamination is remediated to concentrations below regulatory standards.

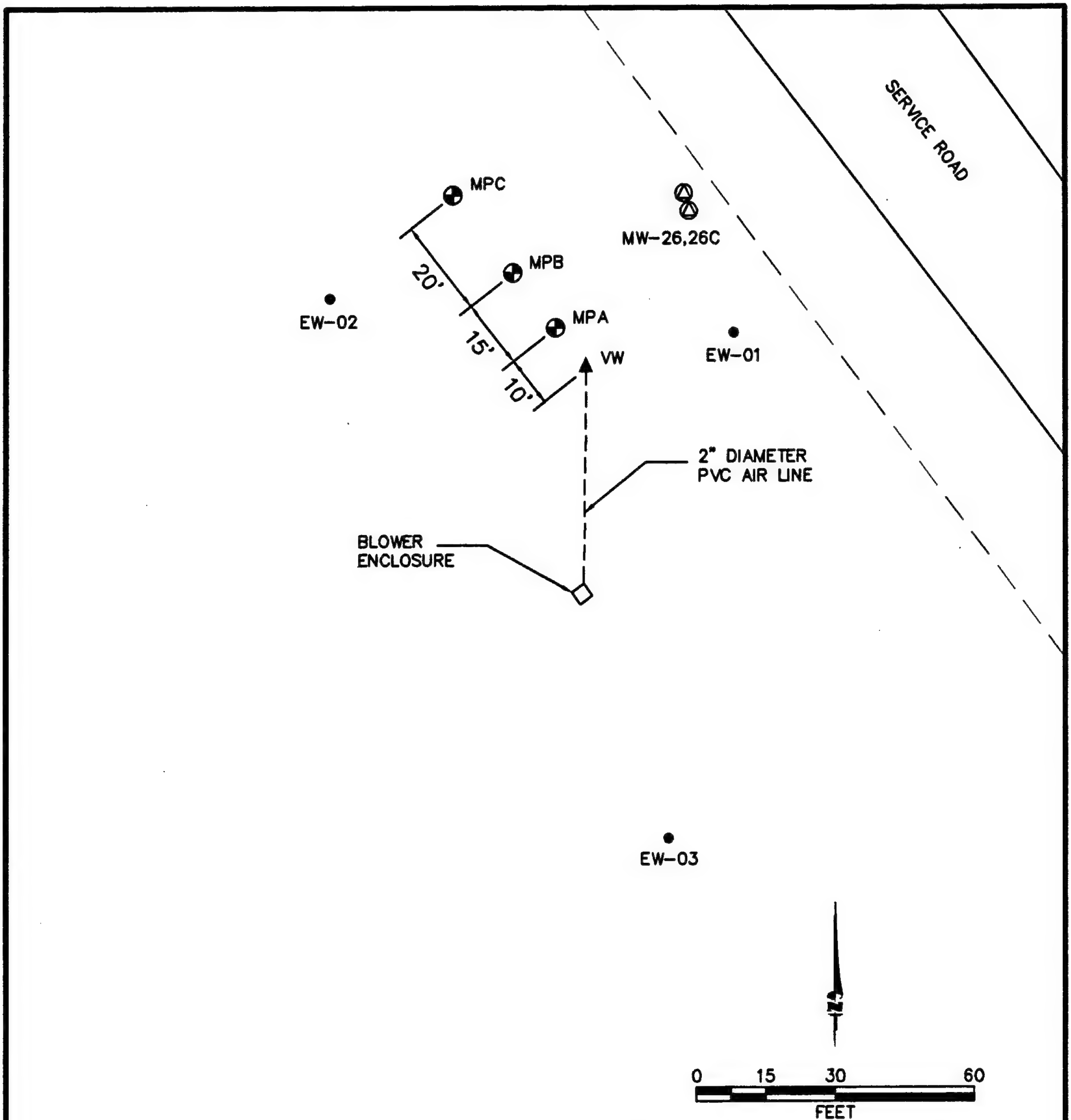
The purpose of this report is to describe the results of the initial pilot tests at Sites 27, 28, and 44 and to make specific recommendations for extended testing to determine the long-term impact of bioventing on site contaminants. Descriptions of the history, geology, and contamination at the sites are contained in Part I, the Bioventing Pilot Test Work Plan.

1.0 PILOT TEST DESIGN AND CONSTRUCTION

Installation of three vapor monitoring points (MPs) and one vent well (VW) at Site 27 took place on January 13 through January 16, 1994. Installation of three MPs and one VW at Site 28 took place on January 19 through January 21, 1994. Installation of three MPs and one VW at Site 44 took place on January 16 through January 19, 1994. Drilling oversight, MP installation, and soil sampling was conducted by Mr. Rusty Frishmuth, ES site manager, and Mr. Scott Pearson, ES test engineer. Drilling services were provided by Enviro-Drill of Phoenix, Arizona, and electrical services were provided by Canyon Electric, Inc. of Las Vegas, Nevada. The following sections describe the final design and installation of the bioventing systems at each site.

1.1 Site 27

Three MPs, one VW, and a blower unit were installed at Site 27. Locations of the VW and MPs completed at the site are shown in Figure 1.1. The hydrogeologic cross-section of the site is shown in Figure 1.2. Boring logs for the MPs and VW are included in Appendix A.



LEGEND

EW-03 ●	PRODUCT RECOVERY WELL
– – – –	CHAINLINK FENCE
MW-24	MONITORING WELL
MPA	VAPOR MONITORING POINT
VW ▲	VENT WELL

FIGURE 1.1

AS-BUILT VENT WELL AND MONITORING POINT LOCATIONS SITE 27

Nellis AFB, Nevada

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Denver, Colorado

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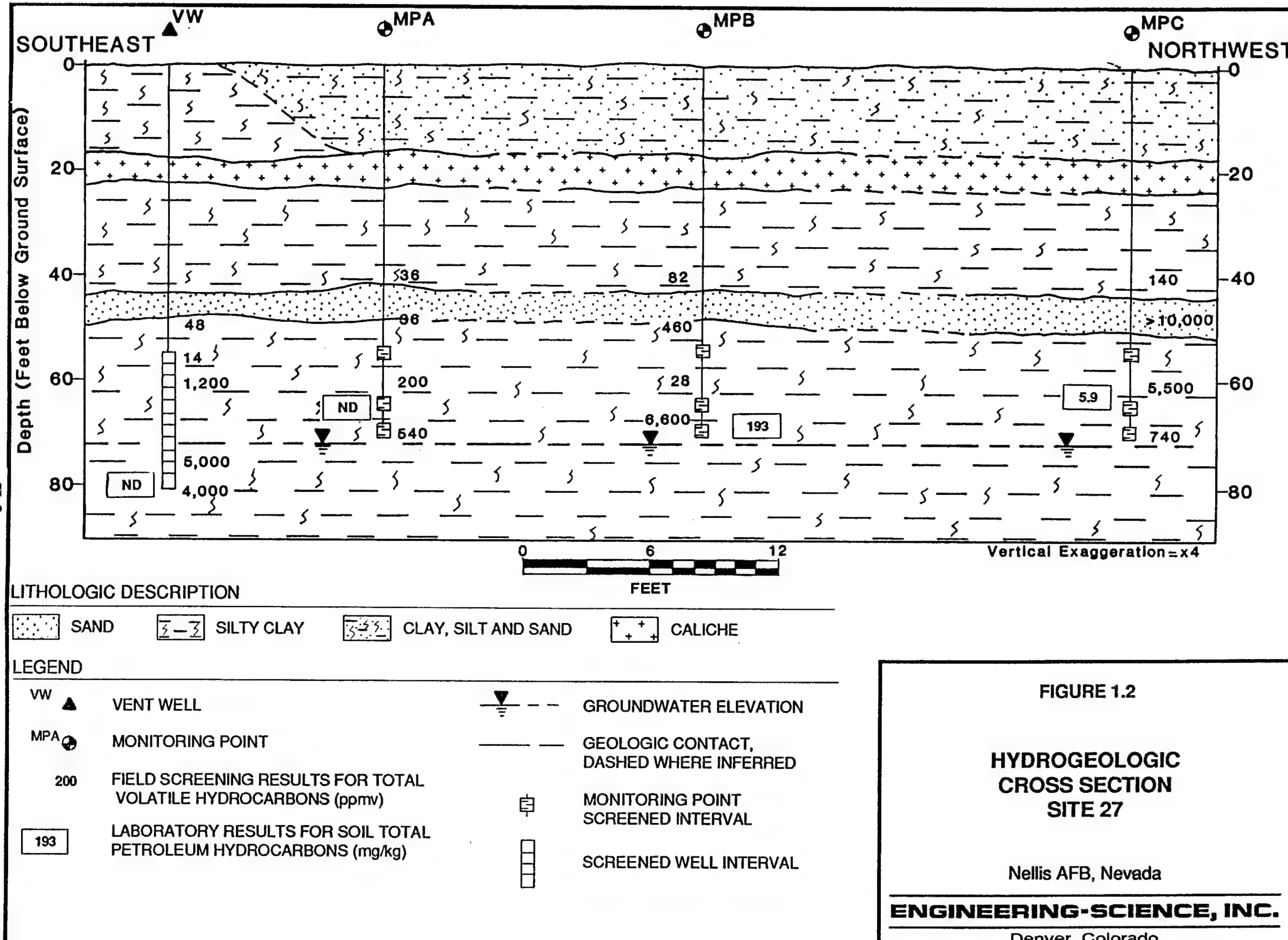


FIGURE 1.2

HYDROGEOLOGIC CROSS SECTION SITE 27

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.
Denver, Colorado

The background MP for this site is MW-6, a monitoring well located approximately 400 feet north of Site 44. MW-6 is screened from 30 to 50 feet below ground surface (bgs) and has approximately 17 feet of screen above the groundwater surface. Soil gas was extracted from this well, however, a soil sample was not collected. A background soil sample will be collected during 1-year testing.

1.1.1 Air Injection Vent Well

The air injection VW was installed following procedures described in the Air Force Center for Environmental Excellence (AFCEE) bioventing protocol document (Hinchee et al., 1992). Figure 1.3 shows construction details for the VW. The VW was installed in contaminated soils with the screened interval extending from 55 to 80 feet bgs. The groundwater surface was approximately 71 feet bgs prior to the pilot test. The VW was constructed using 4-inch-diameter, Schedule 40 polyvinyl chloride (PVC) casing, with 25 feet of 0.04-inch slotted PVC screen. The annular space between the well casing and borehole was filled with 6-9 grain-size silica sand from the bottom of the borehole to approximately 3 feet above the well screen. Five feet of 0.25-inch bentonite pellets was placed above the sand in 6-inch lifts and hydrated in place. Forty-four feet of granular bentonite was placed above the pellets and hydrated in place. The VW was completed with a PVC tee set approximately 1 foot bgs. The tee was then covered with a well box set at the ground surface.

1.1.2 Monitoring Points

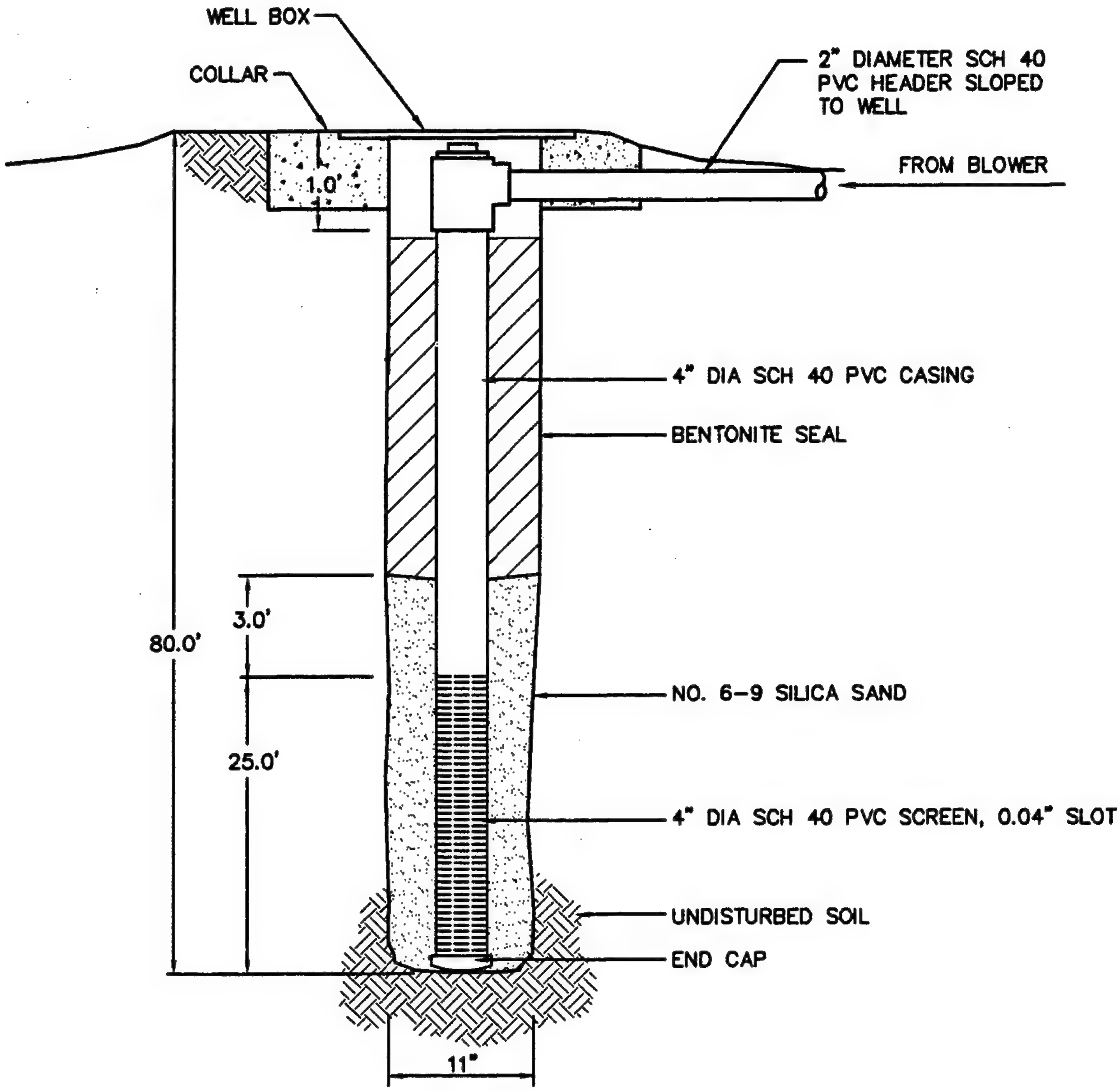
MP screens were installed at 55, 65, and 70 feet bgs. The three MPs (MPA, MPB, and MPC) at this site were constructed as shown in Figure 1.4. MPA, MPB, and MPC were installed 10, 25, and 45 feet from the VW, respectively. Each was constructed using 6-inch sections of 1-inch-diameter PVC well screen with 0.25-inch PVC riser pipes extending to the ground surface. At the top of each riser, a ball valve and a 3/16-inch hose barb were installed. The top of each MP was completed with a flush-mounted metal well protector set in concrete. A thermocouple was installed at the 70-foot depth at MPA to measure soil temperature variations.

1.1.3 Blower Unit

A 1-horsepower Gast® regenerative blower was installed at Site 27 for the initial and extended pilot test. During the initial pilot test, the blower was energized by 208-volt, single-phase, 20-amp power from a temporary receptacle mounted on a post by Canyon Electric; for the extended pilot test, the unit has been hard-wired to a newly installed disconnect mounted on the post. The blower was configured to inject approximately 40 standard cubic feet per minute (scfm) for the extended pilot test. The configuration, instrumentation, and specifications for the extended pilot test blower unit are shown on Figure 1.5. Prior to departing from the site, ES engineers provided an operations and maintenance (O&M) briefing checklist and blower maintenance manual to base personnel. A copy of the checklist is provided in Appendix B.

1.2 Site 28

Three MPs, one VW, and a blower unit were installed at Site 28. Locations of the VW and MPs completed at the site are shown on Figure 1.6. The hydrogeologic cross-section for the site is



NOT TO SCALE

FIGURE 1.3

AS-BUILT AIR NJECTION VENT WELL CONSTRUCTION DETAIL SITE 27

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.

Denver, Colorado

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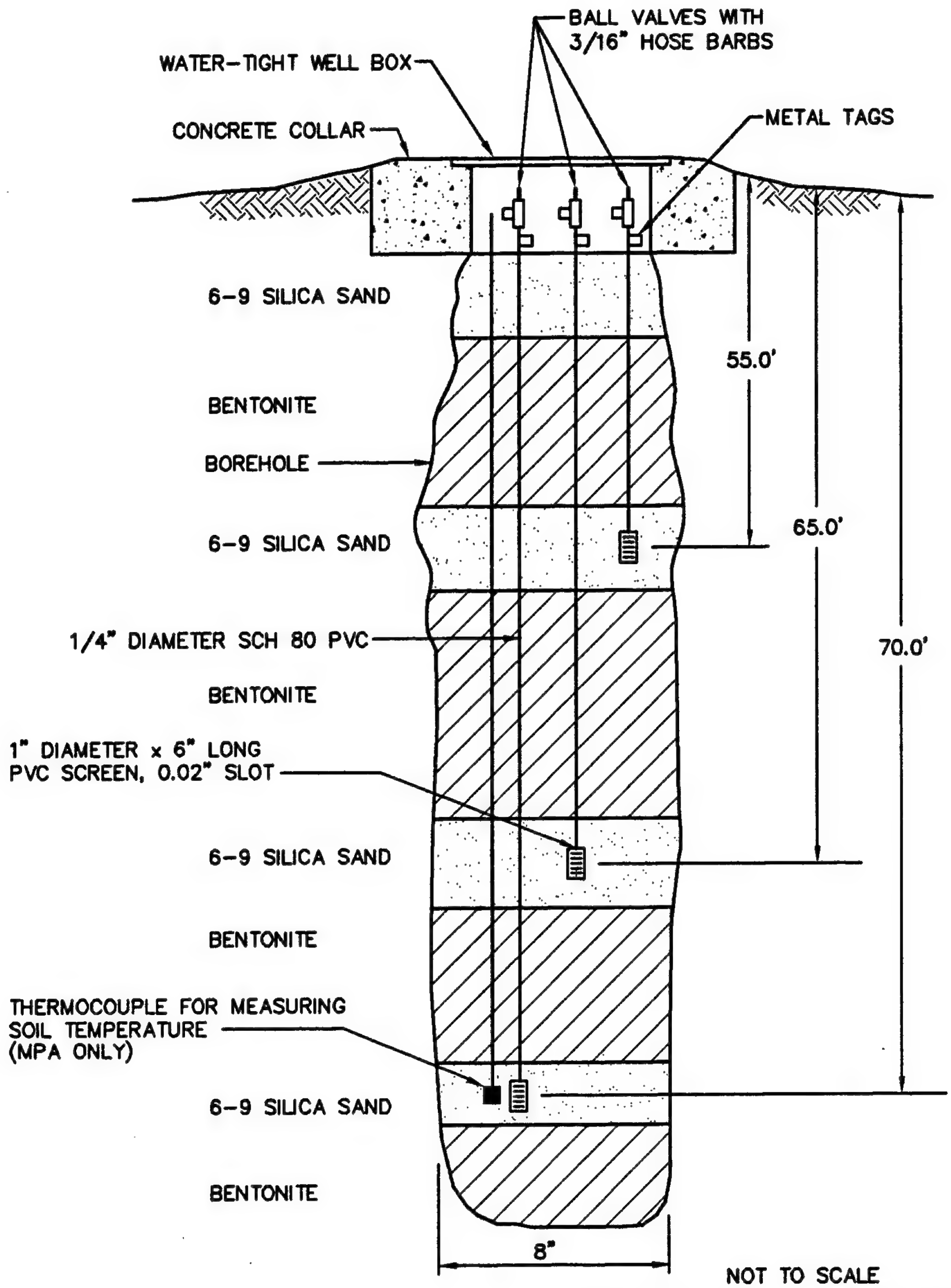


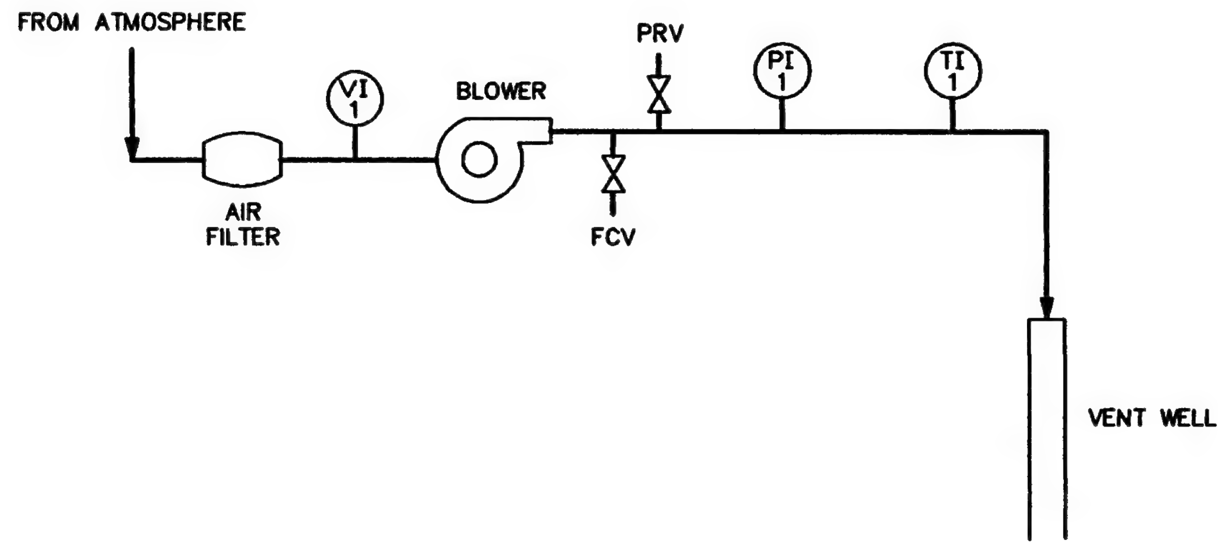
FIGURE 1.4

TYPICAL AS-BUILT MONITORING POINT CONSTRUCTION DETAIL SITE 27

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.

Denver, Colorado



LEGEND

VI 1	VACUUM INDICATOR 0–60" H_2O
PI 1	PRESSURE INDICATOR 0–100" H_2O
TI 1	TEMPERATURE INDICATOR 0–250°F
FCV	FLOW CONTROL VALVE
PRV	PRESSURE RELIEF VALVE SET AT 50" H_2O

FIGURE 1.5

AS-BUILT BLOWER SYSTEM
INSTRUMENTATION DIAGRAM
FOR AIR INJECTION
SITE 27

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.
Denver, Colorado

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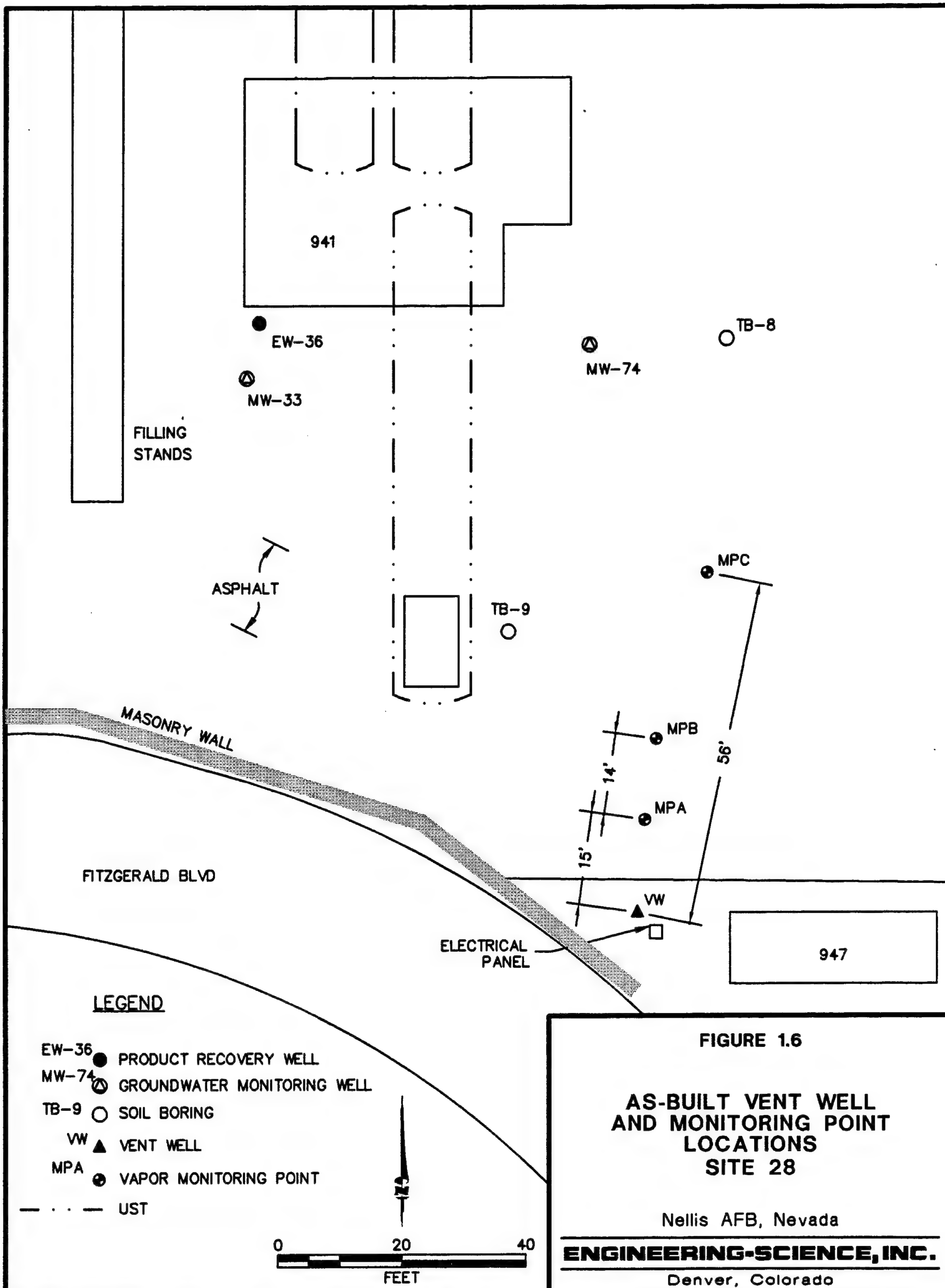

FIGURE 1.6

AS-BUILT VENT WELL AND MONITORING POINT LOCATIONS SITE 28

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.

Denver, Colorado

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shown on Figure 1.7. Boring logs for the MPs and VW are included in Appendix A. The background MP for this site is MW-6, a monitoring well located in similar soils approximately 400 feet north of Site 44. The well is screened from 30 to 50 feet bgs and has approximately 17 feet of screen above the groundwater surface. Soil gas was extracted from this well, however, a soil sample was not collected. A background soil sample will be collected during 1-year testing.

1.2.1 Air Injection Vent Well

The air injection VW was installed following procedures described in the AFCEE bioventing protocol document (Hinchee et al., 1992). Figure 1.8 shows construction details for the VW. The VW was installed in contaminated soils with the screened interval extending from 30 to 65 feet bgs. The groundwater surface at this site prior to the test varied from approximately 50 feet bgs at MPC to approximately 63.5 feet bgs at the VW. The VW was constructed using 4-inch-diameter, Schedule 40 PVC casing, with 35 feet of 0.04-inch slotted PVC screen. The annular space between the well casing and borehole was filled with 6-9 grain size silica sand from the bottom of the borehole to approximately 3 feet above the well screen. Five feet of 1/4-inch bentonite pellets was placed above the sand in 6-inch lifts and hydrated in place. Twenty feet of granular bentonite was placed above the pellets, hydrated in place, and overlaid with a concrete seal to the existing gravel surface.

1.2.2 Monitoring Points

MP screens were installed at 30-, 40-, 50-, and 60-foot depths at MPA and MPB. Due to elevated groundwater at MPC, a 60-foot screen was not possible; MPC screens were installed at 30, 40, and 50 feet bgs. Four screens were installed at MPA and MPB when it was discovered that contamination extended over a 35 foot interval and several soil types. The three MPs (MPA, MPB, and MPC) at this site were constructed as shown in Figure 1.9. MPA, MPB, and MPC were installed 15, 29, and 56 feet from the VW, respectively (Figure 1.6). The uneven spacing of the MPs was necessary to avoid several underground utilities in the area. Each MP was constructed using 6-inch sections of 1-inch-diameter PVC well screen and 0.25-inch PVC riser pipes extending to the ground surface. At the top of each riser, a ball valve and a 3/16-inch hose barb were installed. The top of each MP was completed with a flush-mounted metal well protector set in concrete. A thermocouple was installed at the 50-foot depth at MPC to measure soil temperature variations.

1.2.3 Blower Unit

A 3-horsepower Roots® positive-displacement blower unit was used at Site 28 for the initial pilot test, and a 1-horsepower Gast® regenerative blower unit was installed at the site for the extended pilot test. The initial pilot test blower was energized by 208-volt, single-phase, 20-amp power from a temporary receptacle mounted on a post outside Building 947. The extended pilot test unit is wired to a newly installed disconnect on the post. The 1-horsepower extended pilot test blower was configured to inject approximately 52 scfm for the extended pilot test. The configuration, instrumentation, and specifications for the extended pilot test blower unit are shown on Figure 1.10. Prior to departing from the site, ES engineers provided an O&M briefing checklist and blower maintenance manual to Base personnel. A copy of the checklist is provided in Appendix B.

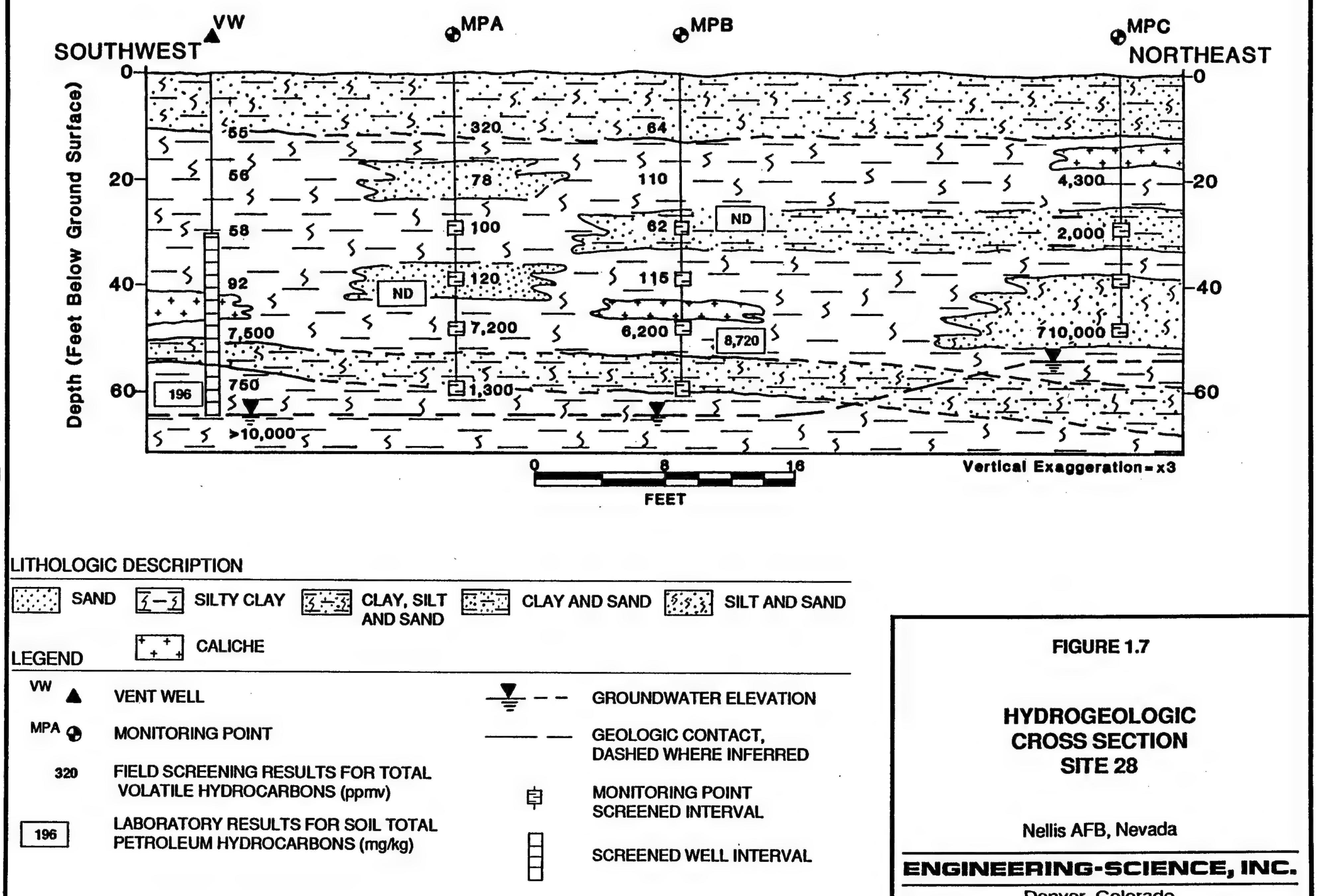
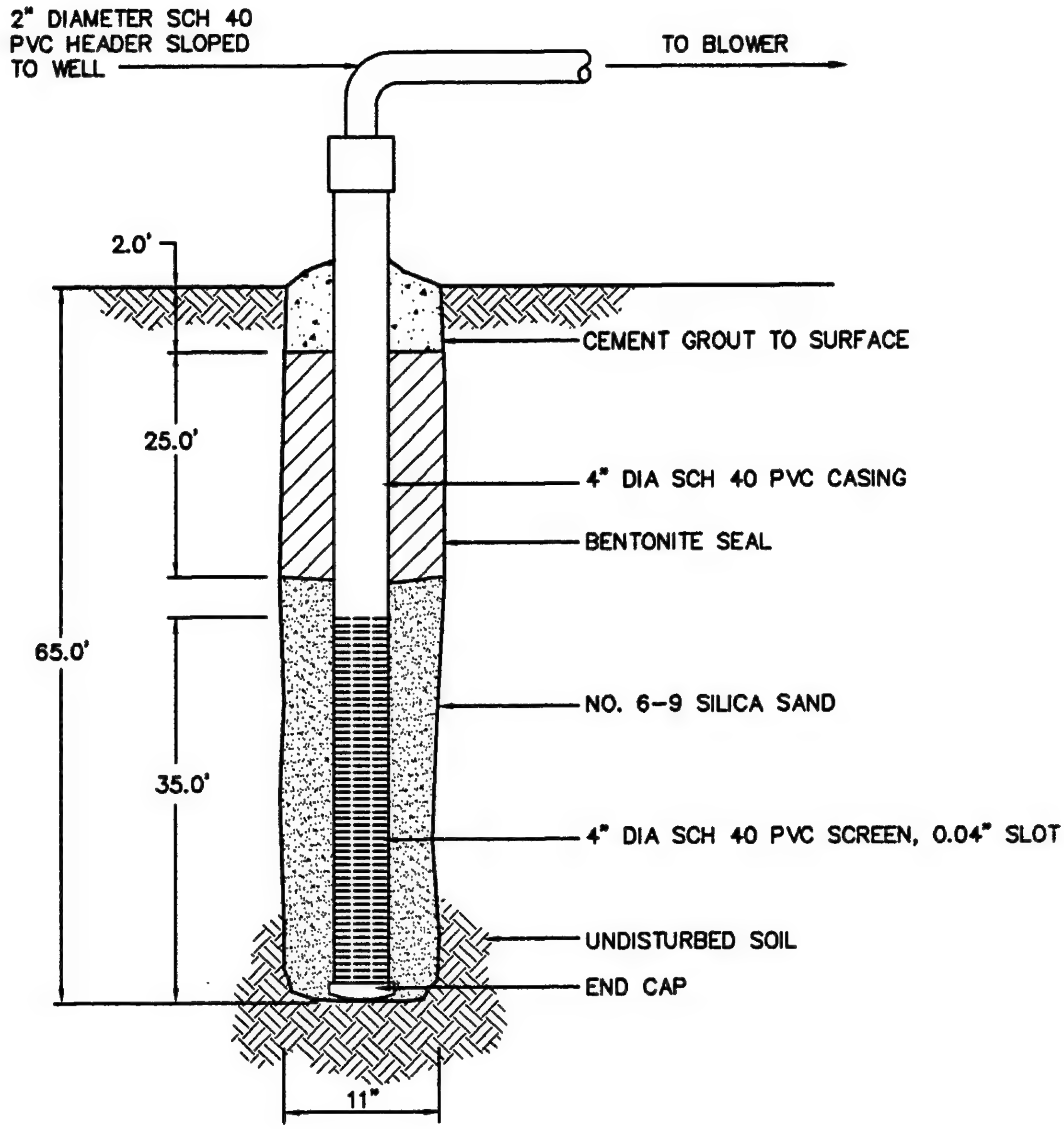


FIGURE 1.7

HYDROGEOLOGIC CROSS SECTION SITE 28

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.
Denver, Colorado



NOT TO SCALE

FIGURE 1.8

AS-BUILT AIR INJECTION
VENT WELL
CONSTRUCTION DETAIL
SITE 28

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.

Denver, Colorado

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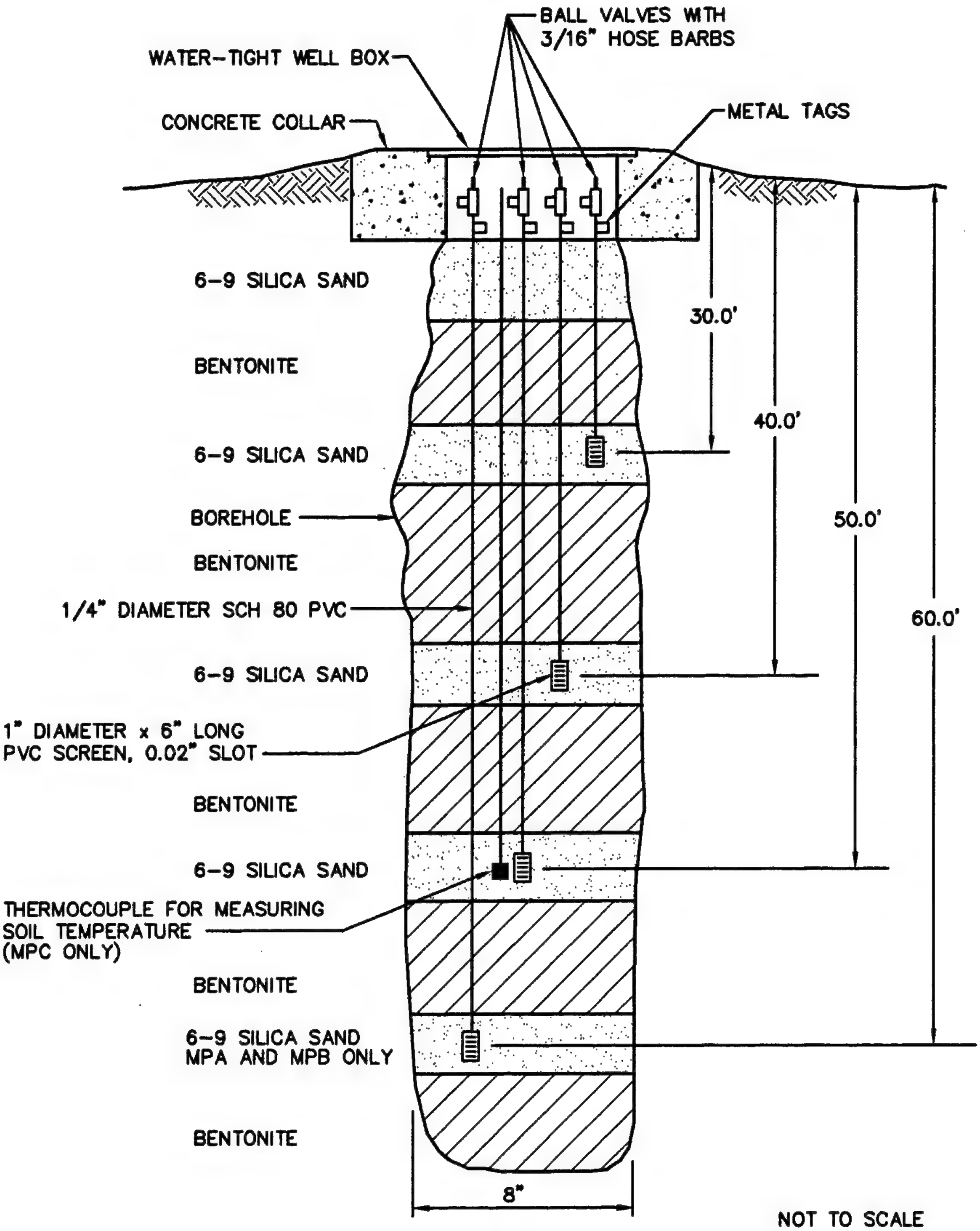


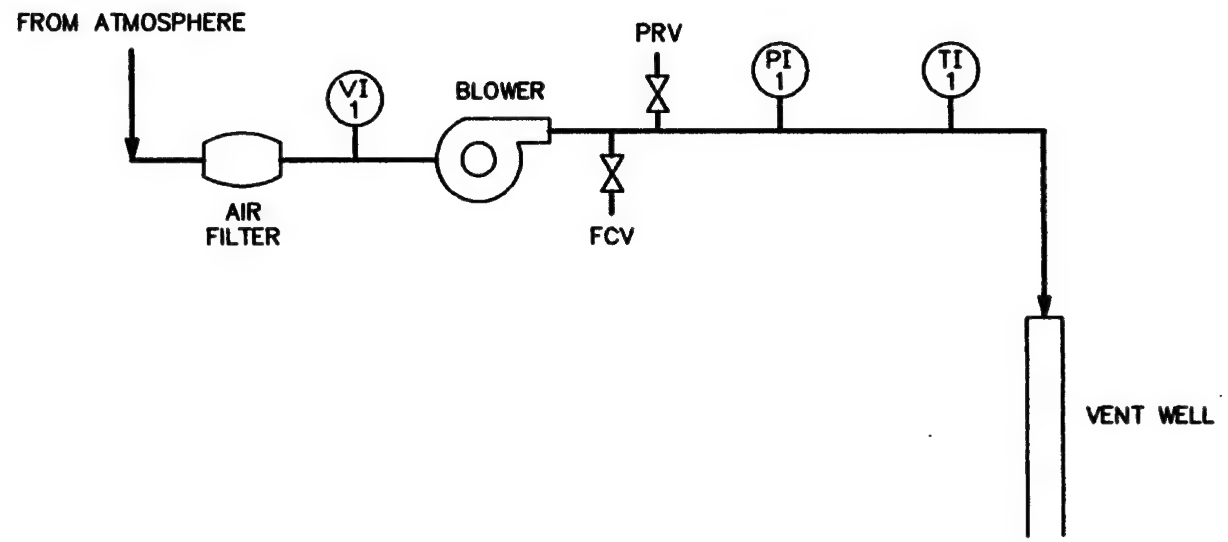
FIGURE 1.9

TYPICAL AS-BUILT MONITORING POINT CONSTRUCTION DETAIL SITE 28

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.

Denver, Colorado



LEGEND

VI 1 — VACUUM INDICATOR 0–60" H_2O

PI 1 — PRESSURE INDICATOR 0–100" H_2O

TI 1 — TEMPERATURE INDICATOR 0–250°F

FCV — FLOW CONTROL VALVE

PRV — PRESSURE RELIEF VALVE SET AT 50" H_2O

FIGURE 1.10

AS-BUILT BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION SITE 28

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.

Denver, Colorado

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1.3 Site 44

Three MPs, one VW, and a blower unit were installed at Site 44. Locations of the VW and MPs completed at the site are shown on Figure 1.11. The hydrogeologic cross-section for the site is shown on Figure 1.12. Boring logs for the MPs and VW are included in Appendix A. The background MP for this site is MW-6, a monitoring well located approximately 400 feet north of the site. The well is screened from 30 to 50 feet bgs and has approximately 17 feet of screen above the groundwater surface. Soil gas was extracted from this well, however, a soil sample was not collected. A background soil sample will be collected during 1-year testing.

1.3.1 Air Injection Vent Well

The air injection VW was installed following procedures described in the AFCEE bioventing protocol document (Hinchee et al., 1992). Figure 1.13 shows construction details for the VW. The VW was installed in contaminated soils with the screened interval extending from 18 to 43 feet bgs. The groundwater surface at this site was approximately 44 feet bgs prior to the pilot test. The VW was constructed using 4-inch-diameter, Schedule 40 PVC casing, with 25 feet of 0.04-inch slotted PVC screen. The annular space between the well casing and borehole was filled with 6-9 grain size silica sand from the bottom of the borehole to approximately 3 feet above the well screen. Sixteen feet of granular bentonite was placed above the sand, hydrated in place, and overlaid with a concrete seal to the existing asphalt surface.

1.3.2 Monitoring Points

The MP screens were installed at 24-, 32-, and 39-foot depths. The three MPs (MPA, MPB, and MPC) at this site were constructed as shown in Figure 1.14. MPA, MPB, and MPC were installed 10, 20, and 35 feet from the VW, respectively. Each was constructed using 6-inch sections of 1-inch-diameter PVC well screen and 0.25-inch PVC riser pipes extending to the ground surface. At the top of each riser, a ball valve and a 3/16-inch hose barb were installed. The top of each MP was completed with a flush-mounted metal well protector set in concrete. A thermocouple was installed at the 39-foot depth at MPA to measure soil temperature variations.

1.3.3 Blower Unit

A 1-horsepower Gast® regenerative blower was installed at Site 44 for the initial and extended pilot test. During the initial pilot test, the blower was energized by 208-volt, single-phase, 20-amp power from a temporary receptacle mounted on a newly installed pole by Canyon Electric; for the extended pilot test, the unit has been hard-wired to a newly installed breaker mounted on the pole. The blower was configured to inject approximately 61 scfm for the extended pilot test. The configuration, instrumentation, and specifications for the extended pilot test unit are shown on Figure 1.15. Prior to departing from the site, ES engineers provided an O&M briefing checklist and blower maintenance manual to base personnel. A copy of the checklist is provided in Appendix B.

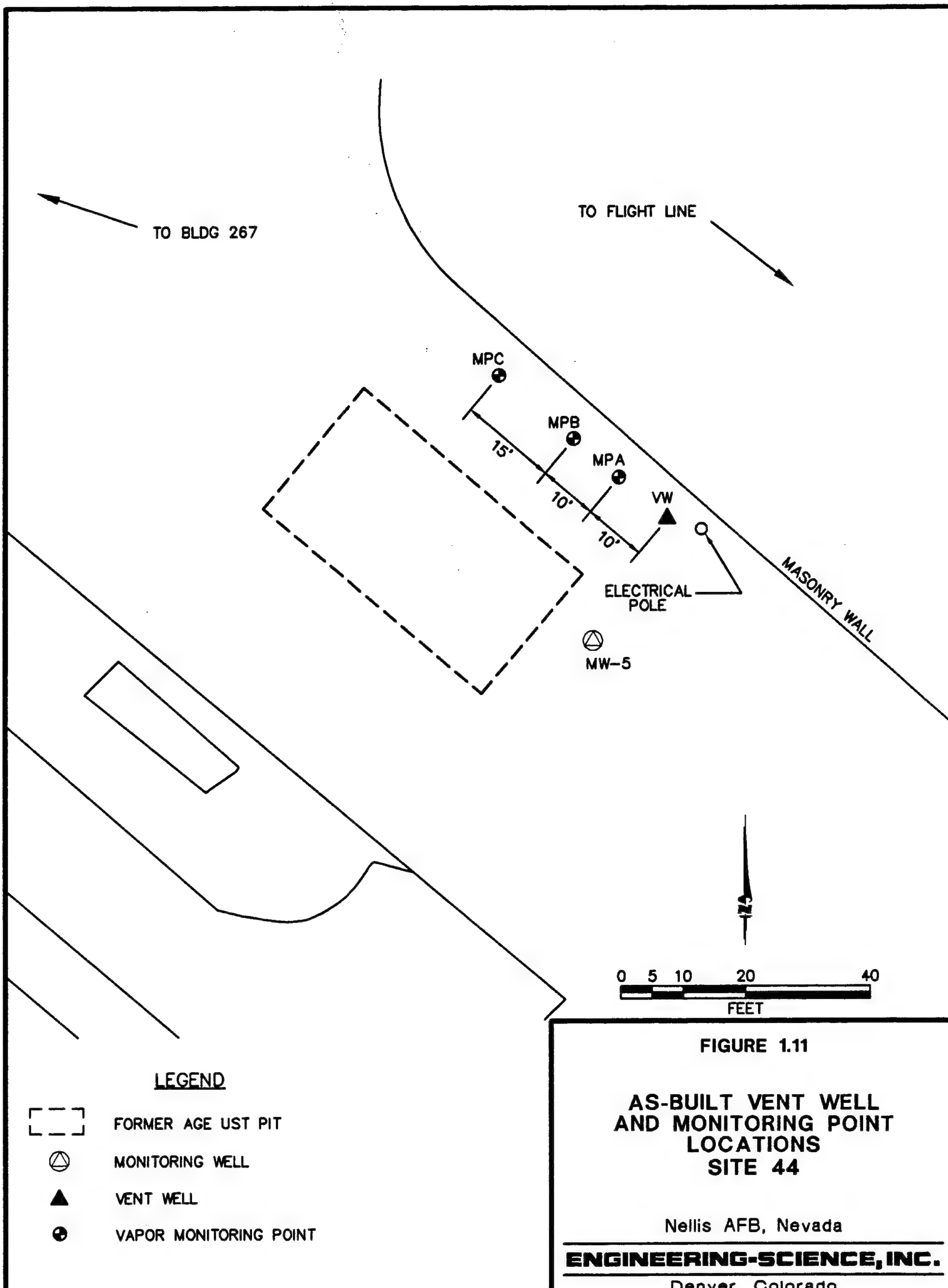

FIGURE 1.11

AS-BUILT VENT WELL AND MONITORING POINT LOCATIONS SITE 44

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.

Denver, Colorado

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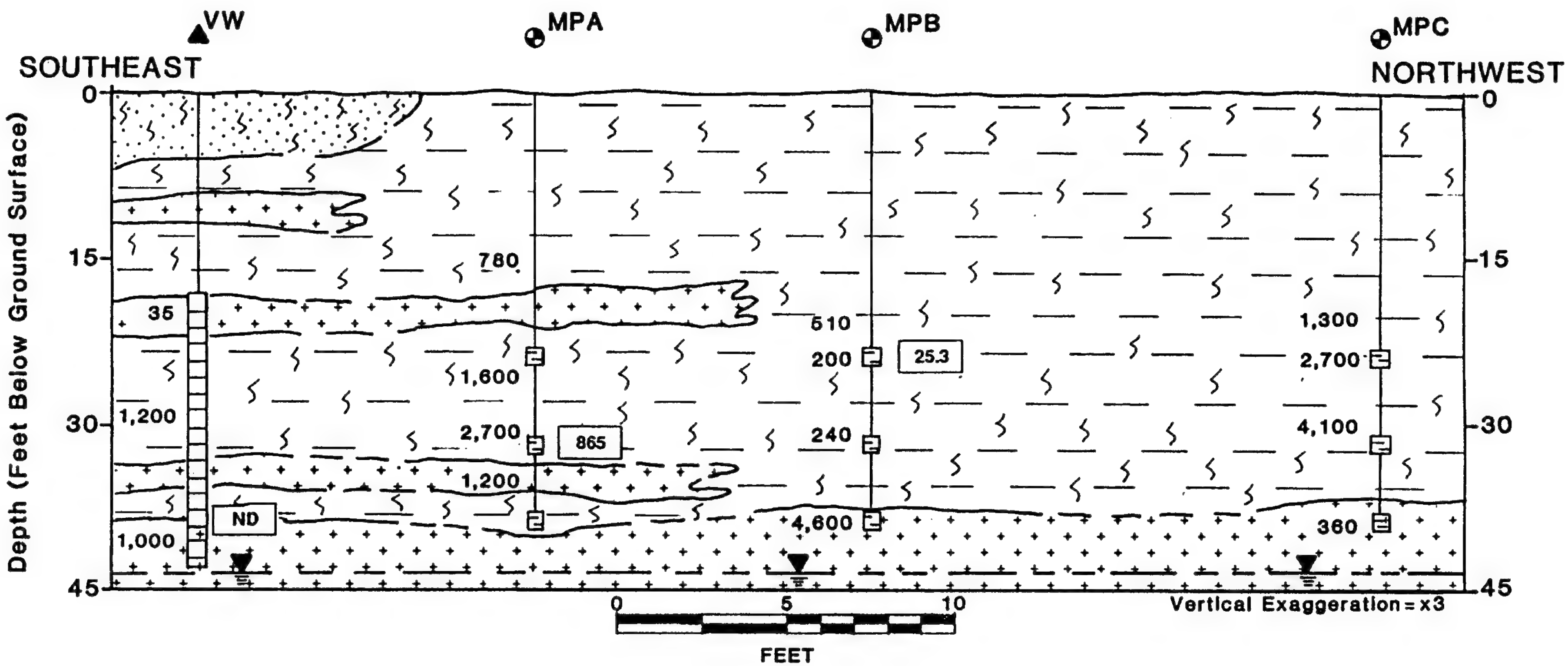


LITHOLOGIC DESCRIPTION

SILTY CLAY

SILT AND SAND

CALICHE

LEGEND

VW — VENT WELL

MPA — MONITORING POINT

780 — FIELD SCREENING RESULTS FOR TOTAL VOLATILE HYDROCARBONS (ppmv)

865 — LABORATORY RESULTS FOR SOIL TOTAL PETROLEUM HYDROCARBONS (mg/kg)

GROUNDWATER ELEVATION

GEOLOGIC CONTACT, DASHED WHERE INFERRED

MONITORING POINT SCREENED INTERVAL

SCREENED WELL INTERVAL

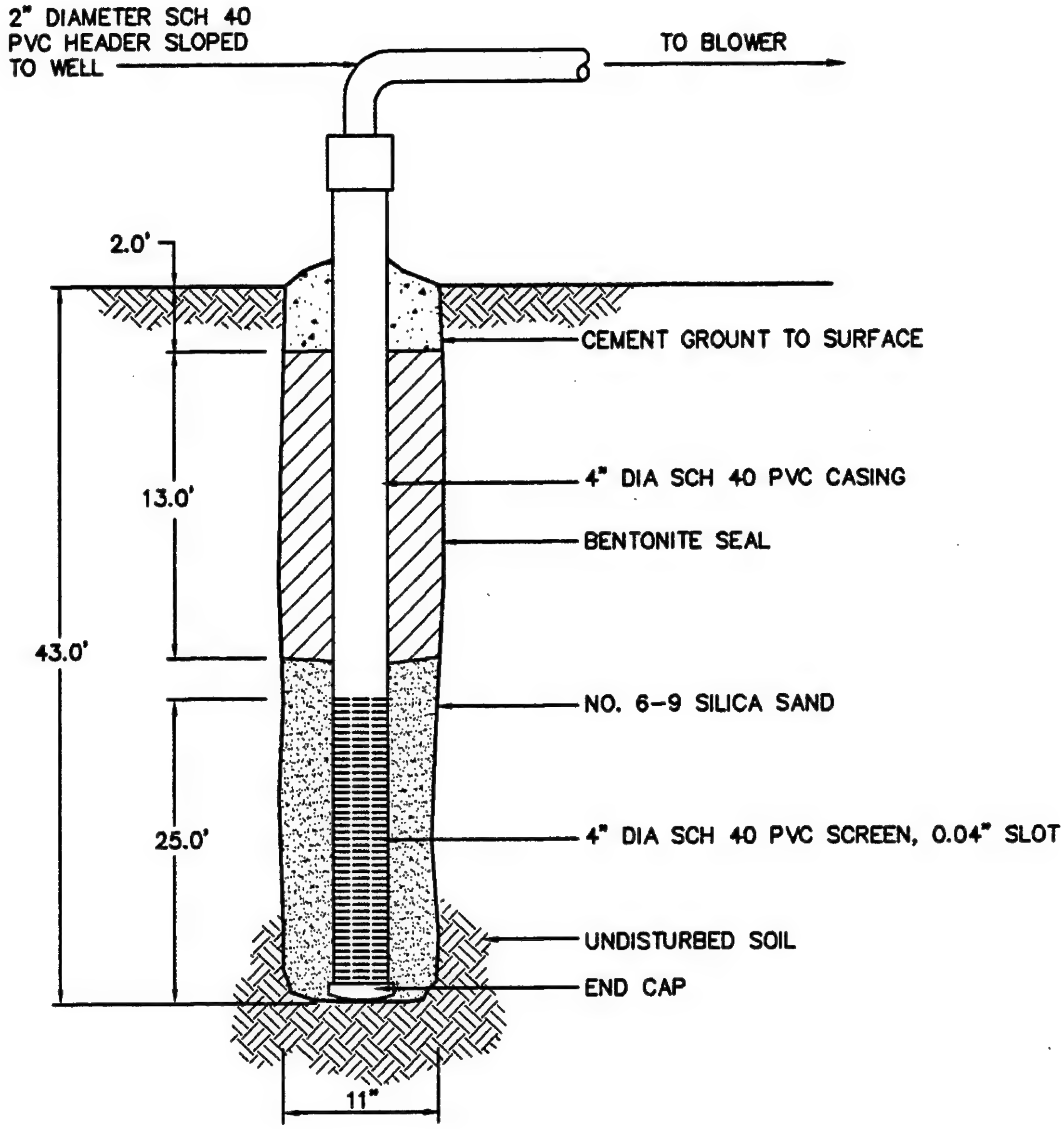
FIGURE 1.12

HYDROGEOLOGIC CROSS SECTION SITE 44

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.

Denver, Colorado



NOT TO SCALE

FIGURE 1.13

AS-BUILT AIR INJECTION VENT WELL CONSTRUCTION DETAIL SITE 44

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.

Denver, Colorado

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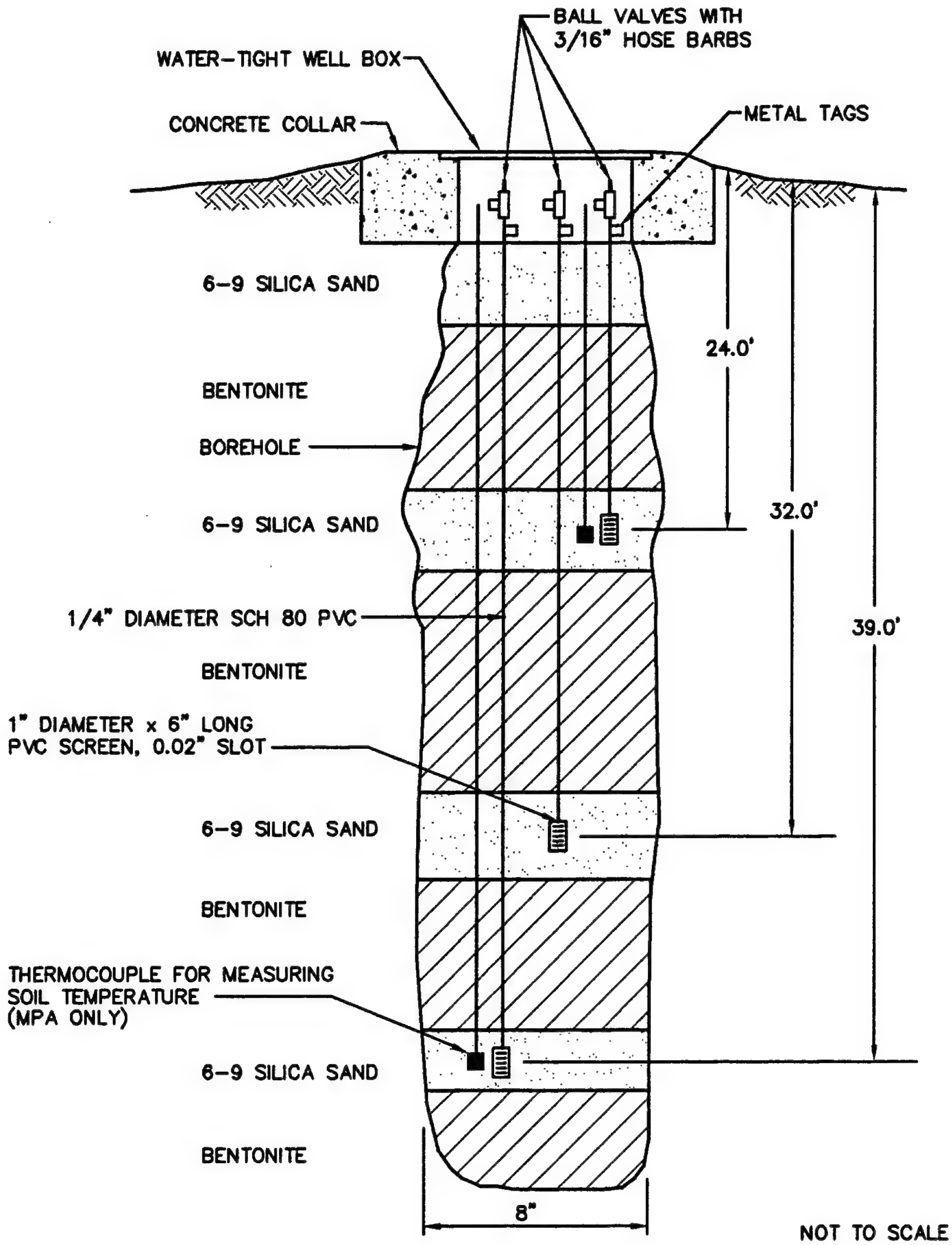


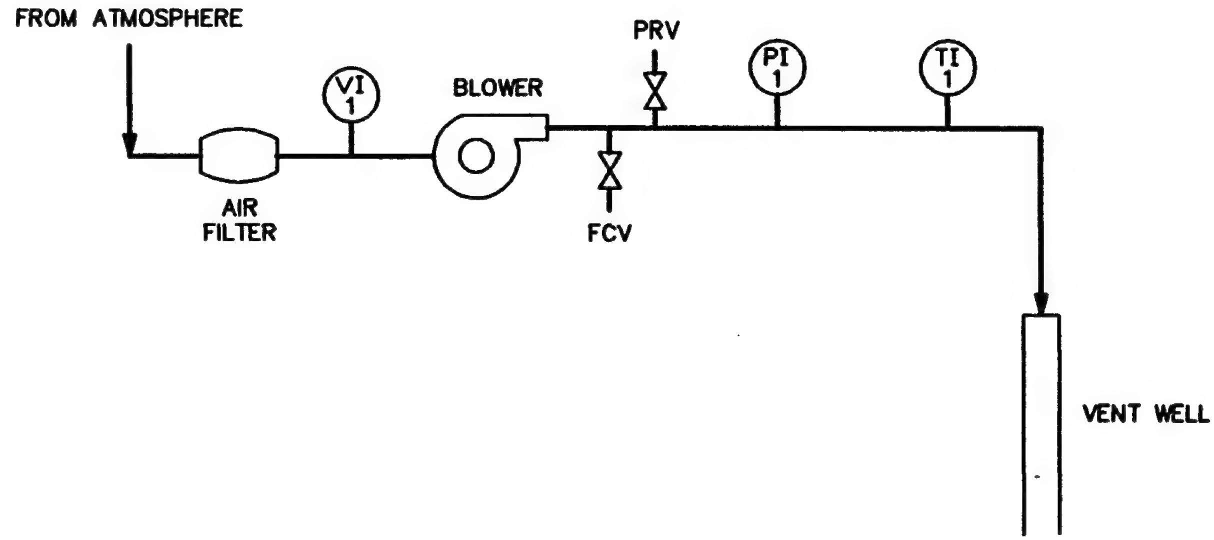
FIGURE 1.14

TYPICAL AS-BUILT MONITORING POINT CONSTRUCTION DETAIL SITE 44

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.

Denver, Colorado



LEGEND

VI 1	VACUUM INDICATOR 0–60" H_2O
PI 1	PRESSURE INDICATOR 0–100" H_2O
TI 1	TEMPERATURE INDICATOR 0–250°F
FCV	FLOW CONTROL VALVE
PRV	PRESSURE RELIEF VALVE SET AT 50" H_2O

FIGURE 1.15

AS-BUILT BLOWER SYSTEM INSTRUMENTATION DIAGRAM FOR AIR INJECTION SITE 44

Nellis AFB, Nevada

ENGINEERING-SCIENCE, INC.
Denver, Colorado

K:\AFCEE\94DN0253, 03/07/94 at 12:50

2.0 PILOT TEST SOIL AND SOIL GAS SAMPLING RESULTS

2.1 Site 27

2.1.1 Sampling Results

Soils at this site generally consist of silty clay with lenses of sand and caliche (Figure 1.2). Bedrock was not encountered during drilling for this pilot test and is not shown on the figure. The general soil profile consists of clay, silt, and sand in the upper 19 feet, a lens of caliche from 19 to 23 feet bgs, silty clay from 23 to approximately 42 feet bgs, a lens of sand from 42 to 45 feet bgs, and silty clay to at least 80 feet bgs. Several other small, isolated lenses of caliche were encountered during drilling. Groundwater occurred at 72 feet bgs in the completed VW. Approximately 0.75 foot of free product was floating on the groundwater surface. Boring logs for the MPs and VW are included in Appendix A.

Hydrocarbon contamination at this site appears to extend from approximately 50 to at least 80 feet bgs. Contaminated soils were identified based on odor and total volatile hydrocarbon (TVH) field screening results. Contaminated soils were encountered in all MP boreholes, with the greatest contamination occurring at 70 feet bgs in MPB (Figure 1.2). Soils at these locations had a strong hydrocarbon odor.

Soil samples for laboratory analysis were collected from split-spoon samplers with 2-inch-diameter brass liners. Soil samples were screened for TVH using a GasTech® TVH analyzer to determine the presence of contamination and to select soil samples for laboratory analysis. Soil samples for laboratory analysis were collected from a depth of 80 from the VW, 65 feet from MPA, 70 feet from MPB, and 65 feet from MPC. Soil gas samples were collected by extracting soil gas from a depth of 55 feet bgs from MPA, 70 feet bgs from MPC, and from the VW.

Soil samples were shipped via Federal Express® to the Pace, Inc. laboratory in Huntington Beach, California for chemical and physical analysis. Soil samples were analyzed for total recoverable petroleum hydrocarbons (TRPH); benzene, toluene, ethylbenzene, and xylenes (BTEX); iron; alkalinity; total Kjeldahl nitrogen (TKN); and several physical parameters. Soil gas samples were shipped via Federal Express® to Air Toxics, Inc. in Folsom, California for TVH and BTEX analysis. The results of these analyses are provided in Table 2.1. Concentrations of soil contaminants appear to be lower than expected when compared to soil gas contaminant concentrations and field observations. Matrix interference appears to be a probable cause for the low laboratory results. Isolated vertical fissures in the soil appeared to contain the majority of the contamination. If soils outside of the fissure zones were collected for laboratory analysis, it is probable that results would be much lower than expected.

2.1.2 Exceptions To Test Protocol Document Procedures

Procedures described in the protocol document (Hinchee et al., 1992) were used to complete treatability tests at Site 27 with a few exceptions. One additional soil sample was analyzed after contamination was discovered in a different soil type and depth at MPC. This sample was included so that the site could be more accurately characterized. One thermocouple was installed at MPA instead of the two prescribed in the test protocol. A 1-

TABLE 2.1

SOIL AND SOIL GAS ANALYTICAL RESULTS
SITE 27
NELLIS AFB, NEVADA

Analyte (Units)[a]	Sample Location-Depth (feet below ground surface)			
Soil Gas Hydrocarbons	VW 55-80	MPA-55	MPC-70	
TVH (ppmv)	89,000	56,000	100,000	
Benzene (ppmv)	390	260	980	
Toluene (ppmv)	240	66	810	
Ethylbenzene (ppmv)	45	25	42	
Xylenes (ppmv)	94	65	140	
Soil Hydrocarbons	VW-80	MPA-65	MPB-70	MPC-65
TRPH (mg/kg)	ND[b]	ND	193	5.9
Benzene (mg/kg)	0.41	0.23	0.51	0.42
Toluene (mg/kg)	0.41	0.022	2.7	4.3
Ethylbenzene (mg/kg)	0.072	0.0076	1.1	2.9
Xylenes (mg/kg)	0.35	0.022	5.4	13
Soil Inorganics	VW-80	MPA-65	MPB-70	MPC-65
Iron (mg/kg)	7,930	9,400	6,350	4,120
Alkalinity (mg/kg as $CaCO_3$)	3,930	480	1690	353
pH (units)	8.7	8.6	8.8	9
TKN (mg/kg)	740	100	70	120
Phosphate (mg/kg)	170	170	130	210
Soil Physical Parameters	VW-80	MPA-65	MPB-70	MPC-65
Moisture (% wt.)	13.2	22.7	14.3	5.7
Gravel (%)	0.0	0.0	0.0	8.4
Sand (%)	21.6	25.5	25.2	28.1
Silt (%)	45.0	41.0	40.7	36.7
Clay (%)	33.4	33.5	34.0	26.8
Soil Temperature (°F)	MPA-70			
	69.4			

[a] mg/kg = milligrams per kilogram; ppmv = parts per million, volume per volume; $CaCO_3$ = calcium carbonate; TKN = total Kjeldahl nitrogen; TVH = total volatile hydrocarbons; TRPH = total reoverable petroleum hydrocarbons; °F = degrees Fahrenheit.

[b] ND = not detected.

horsepower regenerative blower was used to perform the permeability test. This blower was used after the motor on the 3-horsepower positive-displacement test blower failed and rendered the blower inoperable. Based on data from the permeability test, the smaller blower appears to have provided sufficient air flow to obtain meaningful results.

2.2 Site 28

2.2.1 Sampling Results

Soils at this site consist primarily of silty clays with layers of caliche and sand (Figure 1.7). Bedrock was not encountered during drilling for this pilot test and is not shown in the figure. The general soil profile consists of clay, silt, and sand to 10 feet bgs; silty clays with layers of caliche and sand to 50 to 60 feet bgs; clay, silt, and sand to 55 to 65 feet bgs; and silty clay to at least 65 feet bgs. The groundwater surface at this site prior to the test varied from approximately 50 feet bgs at MPC to approximately 63.5 feet bgs at the VW. Boring logs for the MPs and VW are included in Appendix A.

Hydrocarbon contamination at this site appears to extend from approximately 30 to at least 65 feet bgs. Contaminated soils were identified based on odor and TVH field screening results. Contaminated soils were encountered in all MP boreholes with the greatest contamination occurring at 50 feet bgs at MPB. Soils at these locations had a strong hydrocarbon odor.

Soil samples for laboratory analysis were collected from split-spoon samplers with 2-inch-diameter brass liners. Soil samples were screened for TVH using a GasTech® TVH analyzer to determine the presence of contamination and to select soil samples for laboratory analysis. Soil samples for laboratory analysis were collected from a depth of 65 feet from the VW, 42 feet from MPA, and 50 feet from MPB. Soil gas samples were collected by extracting soil gas from a depth of 50 feet bgs from MPA, 30 feet bgs from MPC, and the VW.

Soil samples were shipped via Federal Express® to the Pace, Inc. laboratory in Huntington Beach, California for chemical and physical analysis. Soil samples were analyzed for TRPH, BTEX, iron, alkalinity, TKN, and several physical parameters. Soil gas samples were shipped via Federal Express® to Air Toxics, Inc. in Folsom, California for TVH and BTEX analysis. The results of these analyses are provided in Table 2.2. Concentrations of soil contaminants appear to be lower than expected when compared to soil gas contaminant concentrations and field observations. Matrix interference appears to be a probable cause for the low laboratory results. Isolated vertical fissures in the soil appeared to contain the majority of the contamination. If soils outside of the fissure zones were collected for laboratory analysis, it is probable that results would be much lower than expected. This is evident when the sample MPB-50 is compared to all of the other samples collected from the area. The area is known to have widespread contamination, yet sample MPB-50 was the only sample that had appreciable concentrations of TRPH or BTEX.

2.2.2 Exceptions To Test Protocol Document Procedures

Procedures described in the protocol document (Hinchee et al., 1992) were used to complete treatability tests at Site 28 with two exceptions. One thermocouple was installed at MPC instead of two at MPA as prescribed in the test protocol. Additionally, two of the MPs,

TABLE 2.2

SOIL AND SOIL GAS ANALYTICAL RESULTS
SITE 28
NELLIS AFB, NEVADA

Analyte (Units)[a/]	Sample Location-Depth (feet below ground surface)			
Soil Gas Hydrocarbons	VW 30-65	MPA-50	MPC-30	
TVH (ppmv)	98,000	80,000	38,000	
Benzene (ppmv)	870	400	290	
Toluene (ppmv)	1000	310	330	
Ethylbenzene (ppmv)	64	20	80	
Xylenes (ppmv)	230	65	260	
Soil Hydrocarbons	VW-65	MPA-42	MPB-50	MPB-30
TRPH (mg/kg)	196	ND[b/]	8,720	ND
Benzene (mg/kg)	29	0.24	25	0.024
Toluene (mg/kg)	120	0.03	140	0.0025
Ethylbenzene (mg/kg)	51	0.033	68	0.0057
Xylenes (mg/kg)	220	0.18	280	0.026
Soil Inorganics	VW-65	MPA-42	MPB-50	MPB-30
Iron (mg/kg)	6,340	6,550	4,520	NS[c/]
Alkalinity (mg/kg as $CaCO_3$)	486	433	315	NS
pH (units)	8.7	8.4	8.7	NS
TKN (mg/kg)	93	110	100	110
Phosphate (mg/kg)	490	230	150	NS
Soil Physical Parameters	VW-65	MPA-42	MPB-50	MPB-30
Moisture (% wt.)	32.3	26.6	16	21.6
Gravel (%)	8.9	25.8	1.4	NS
Sand (%)	49.0	40.1	55.2	NS
Silt (%)	27.0	20.4	28.1	NS
Clay (%)	15.1	13.7	15.3	NS
Soil Temperature (°F)	MPC-50			
	73.8			

a/ mg/kg = milligrams per kilogram; ppmv = parts per million, volume per volume; $CaCO_3$ = calcium carbonate; TKN = total Kjeldahl nitrogen; TVH = total volatile hydrocarbons; TRPH = total reoverable petroleum hydrocarbons; °F = degrees Fahrenheit.

b/ ND = not detected.

c/ NS = not sampled.

MPA and MPB, were constructed with four screened monitoring intervals instead of the typical three. Four monitoring depths were installed because the contaminated soil interval discovered at the site was so large.

2.3 Site 44

2.3.1 Sampling Results

Soils at this site generally consist of silty clays with lenses of caliche (Figure 1.12). Bedrock was not encountered during drilling for this pilot test and is not shown on the figure. The general soil profile consists of silty clay throughout the test interval with lenses of caliche at 11, 20, 35, and 39 feet bgs. A small interval of silt and sand was encountered at the surface at the VW. Groundwater occurred at 44 feet bgs in the VW borehole. Boring logs for the MPs and VW are included in Appendix A.

Hydrocarbon contamination at this site appears to extend from approximately 20 to at least 44 feet bgs. Contaminated soils were identified based on odor and TVH field screening results. Contaminated soils were encountered in all MP boreholes, with the greatest contamination occurring at 32 feet bgs in MPA. Soils at these locations had a strong hydrocarbon odor (Figure 1.12).

Soil samples for laboratory analysis were collected from split-spoon samplers with 2-inch-diameter brass liners. Soil samples were screened for TVH using a GasTech® TVH analyzer to determine the presence of contamination and to select soil samples for laboratory analysis. Soil samples for laboratory analysis were collected from a depth of 40 from the VW, 32 feet from MPA, and 24 feet from MPB. Soil gas samples were collected by extracting soil gas from a depth of 32 feet bgs from MPA, 39 feet bgs from MPC, and the VW.

Soil samples were shipped via Federal Express® to the Pace, Inc. laboratory in Huntington Beach, California for chemical and physical analysis. Soil samples were analyzed for TRPH, BTEX, iron, alkalinity, TKN, and several physical parameters. Soil gas samples were shipped via Federal Express® to Air Toxics, Inc. in Folsom, California for TVH and BTEX analysis. The results of these analyses are provided in Table 2.3. Concentrations of soil contaminants appear to be lower than expected when compared to soil gas contaminant concentrations and field observations. Matrix interference appears to be a probable cause for the low laboratory results. Isolated vertical fissures in the soil appeared to contain the majority of the contamination. If soils outside of the fissure zones were collected for laboratory analysis, it is probable that results would be much lower than expected.

2.3.2 Exceptions To Test Protocol Document Procedures

Procedures described in the protocol document (Hinchee et al., 1992) were used to complete treatability tests at Site 44 with two exceptions. One thermocouple was installed at MPA instead of the two prescribed in the test protocol. A 1-horsepower regenerative blower was used to perform the permeability test. This blower was used after the motor on the 3-horsepower positive displacement test blower failed and rendered the blower inoperable. Based on data from the permeability test, the smaller blower provided sufficient air flow to obtain meaningful results.

TABLE 2.3

**SOIL AND SOIL GAS ANALYTICAL RESULTS
SITE 44
NELLIS AFB, NEVADA**

Analyte (Units)[a]	Sample Location-Depth (feet below ground surface)		
Soil Gas Hydrocarbons	VW 18-43	MPA-32	MPC-39
TVH (ppmv)	20,000	23,000	45,000
Benzene (ppmv)	99	140	370
Toluene (ppmv)	760	1000	500
Ethylbenzene (ppmv)	74	79	50
Xylenes (ppmv)	460	500	170
Soil Hydrocarbons	VW-40	MPA-32	MPB-24
TRPH (mg/kg)	ND[b]	865	25.3
Benzene (mg/kg)	3.7	ND	ND
Toluene (mg/kg)	6	150	2.7
Ethylbenzene (mg/kg)	0.96	77	7.1
Xylenes (mg/kg)	4.2	240	74
Soil Inorganics	VW-40	MPA-32	MPB-24
Iron (mg/kg)	12,000	2,900	5,360
Alkalinity (mg/kg as $CaCO_3$)	625	198	1570
pH (units)	8.2	8.4	8.8
TKN (mg/kg)	140	ND	ND
Phosphate (mg/kg)	430	74	120
Soil Physical Parameters	VW-40	MPA-32	MPB-24
Moisture (% wt.)	45.9	10.5	18.4
Gravel (%)	47.7	0.7	15.8
Sand (%)	20.0	30.2	40.8
Silt (%)	18.1	29.8	27.3
Clay (%)	14.2	39.3	16.0
Soil Temperature (°F)	MPA-39		
	74.0		

[a] mg/kg = milligrams per kilogram; ppmv = parts per million, volume per volume; $CaCO_3$ = calcium carbonate; TKN = total Kjeldahl nitrogen; TVH = total volatile hydrocarbons; TRPH = total reoverable petroleum hydrocarbons; °F = degrees Fahrenheit.

[b] ND = not detected.

3.0 PILOT TEST RESULTS

3.1 Site 27

3.1.1 Initial Soil Gas Chemistry

Prior to initiating any air injection, all MPs and the VW were purged until oxygen levels had stabilized, and initial oxygen, carbon dioxide, and TVH concentrations were sampled using portable gas analyzers as described in the protocol document (Hinchee et al., 1992). At all MP screened intervals sampled, microorganisms had significantly depleted soil gas oxygen supplies, indicating significant biological activity and soil contamination. Table 3.1 summarizes the initial soil gas chemistry.

3.1.2 Air Permeability

An air permeability test was conducted according to protocol document procedures. Air was injected into the VW for 21.5 hours at a rate of approximately 7.0 scfm and an average pressure of 1.5 pounds per square inch (psi). The maximum pressure response at each MP is listed in Table 3.2. The pressure measured at the MPs quickly increased at a regular rate throughout the period of air injection. Due to the short-term pressure response, the steady-state method of determining air permeability was selected. A soil gas permeability value of 2.9 darcys, typical for clay soils, was calculated for this site. A radius of pressure influence of at least 45 feet was observed at the 55- and 70-foot depths.

3.1.3 Oxygen Influence

The depth and radius of oxygen increase in the subsurface resulting from air injection into the central VW during pilot testing is the primary design parameter for full-scale bioventing systems. Optimization of full-scale and multiple VW systems requires pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 3.3 presents the change in soil gas oxygen levels that occurred during the 21.5-hour air permeability test. Since the permeability test was conducted with the same blower that will be used for the 1-year extended pilot tests, these oxygen influence results are indicative of what the long-term results will be. This period of air injection at approximately 7.0 scfm produced changes in soil gas oxygen levels at all of the functioning MP screened intervals. Based on measured changes in oxygen levels, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 45 feet at the 55- and 70-foot depths. Good oxygen influence above and below the layer at 65 feet bgs should lead to oxygen diffusion into these low-permeability soils. Monitoring during the extended pilot test at this site will better define the effective treatment radius.

3.1.4 *In Situ* Respiration Rates

The *in situ* respiration test was performed by injecting a mixture of air (oxygen) and approximately 1.9 percent helium (inert tracer gas) into three MP screened intervals (MPA-70, MPB-55, and MPC-55) and the VW for a 19-hour period. Oxygen loss and other changes in soil gas composition over time were then measured at these intervals and at all other MP intervals which had elevated oxygen levels following the air injection. Oxygen, TVH, carbon dioxide, and helium were measured for a period of approximately 9 days following air

TABLE 3.1

INITIAL SOIL GAS CHEMISTRY
SITE 27
NELLIS AFB, NEVADA

Sample Location	Depth (ft)	O_2 (%)	CO_2 (%)	Field TVH (ppmv)[a/]	Lab TVH (ppmv)[b/]	Soil TRPH (mg/kg)[c/]
MPA	55	0.5	10.0	>20,000	56,000	NS[d/]
MPB	55	0.7	11.0	>20,000	NS	NS
MPC	55	1.8	9.5	>20,000	NS	NS
MPA	65	---[e/]	---	---	---	ND[f/]
MPB	65	---	---	---	---	NS
MPC	65	---	---	---	---	5.9
MPA	70	1.0	1.0	>20,000	NS	NS
MPB	70	2.5	0.9	>20,000	NS	193
MPC	70	2.9	0.8	>20,000	100,000	NS
VW	55-80	2.0	8.1	>20,000	89,000	ND[g/]

a/ Field screening results, in parts per million, volume per volume (ppmv).
b/ Laboratory results.
c/ Laboratory soil results, in milligrams per kilogram (mg/kg).
d/ NS = not sampled.
e/ --- = unable to collect sample due to tight soil conditions.
f/ ND = not detected.
g/ Sample collected from 80 feet bgs.

TABLE 3.2

MAXIMUM PRESSURE RESPONSE
AIR PERMEABILITY TEST
SITE 27
NELLIS AFB, NEVADA

	Distance from VW (feet)								
		10 (MPA)			25 (MPB)			45 (MPC)	
Depth (feet)	55	65	70	55	65	70	55	65	70
Time (min)	1,140	1,140	1,140	1,140	1,140	1,140	1,140	25	1,140
Max Press. (inches H_2O)	6.30	0.82	11.5	3.10	1.70	8.80	3.05	0.13	8.40

TABLE 3.3

INFLUENCE OF AIR INJECTION AT VENT WELL ON MONITORING POINT OXYGEN LEVELS SITE 27 NELLIS AFB, NEVADA

MP	Distance From VW (ft)	Depth (ft)	Inital O_2 (%)	Final O_2 (%)[a/]
A	10	55	0.5	20.7
B	25	55	0.7	20.4
C	45	55	1.8	17.9
A	10	65	---[b/]	---
B	25	65	---	---
C	45	65	---	---
A	10	70	1.0	18.2
B	25	70	2.5	20.6
C	45	70	2.9	20.3

a/ Reading taken after approximately 21.5 hours of injection using long-term blower system.

b/ --- = unable to collect sample due to tight soil conditions.

injection. The measured oxygen losses were then used to calculate biological oxygen utilization rates. The results of *in situ* respiration testing for the MP intervals at this site are presented in Figures 3.1 through 3.4. Additional respiration test results are included in Appendix A. Table 3.4 provides a summary of the oxygen utilization rates.

Because helium is a conservative, inert gas, the change in helium concentrations over time can be useful in determining the effectiveness of the bentonite seals between MP screened intervals. Figures 3.1 through 3.4 compare oxygen utilization and helium retention. Because the observed helium loss was negligible, and because helium will diffuse approximately three times faster than oxygen due to oxygen's greater molecular weight, the measured oxygen loss is the result of bacterial respiration and is not due to faulty MP construction.

Oxygen loss occurred at slow rates, ranging from 0.0001 percent per minute at MPC-55 to 0.0038 percent per minute at the VW. At the VW, oxygen dropped from 20.6 percent to 12.7 percent in 1,980 minutes.

Based on these oxygen utilization rates, an estimated 40 to 150 milligrams (mg) of fuel per kilogram (kg) of soil can be degraded each year at this site. This conservative estimate is based on an average air-filled porosity of approximately 0.14 liter per kg of soil, and a ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. If oxygen can be uniformly distributed in these soils, moderate long-term remediation of fuel hydrocarbons is predicted.

3.1.5 Potential Air Emissions

The long-term potential for air emissions from full-scale bioventing operations at this site is low because of the air injection depth. Accumulated vapors will move slowly outward from the air injection VW, and vapor-phase hydrocarbons will be biodegraded as they move horizontally through the soil.

3.2 Site 28

3.2.1 Initial Soil Gas Chemistry

Prior to initiating any air injection, all MPs and the VW were purged until oxygen levels had stabilized, and initial oxygen, carbon dioxide, and TVH concentrations were sampled using portable gas analyzers, as described in the protocol document (Hinchee et al., 1992). At all MP screened intervals sampled, microorganisms had significantly depleted soil gas oxygen supplies, indicating significant biological activity and soil contamination. Table 3.5 summarizes the initial soil gas chemistry.

3.2.2 Air Permeability

An air permeability test was conducted according to protocol document procedures. Air was injected into the VW for 18 hours at a flow rate of approximately 27 scfm and an average pressure of 3.0 psi. The maximum pressure response at each MP are presented in Table 3.6. The pressure measured at the MPs quickly increased regularly during the period of air injection. Due to the short-term pressure response, the steady-state method of determining air permeability was selected. A soil gas permeability value of 1.01 darcys, typical for clay soils, was calculated for this site. A radius of pressure influence of at least 56 feet was observed in soils below 30 feet bgs.

Figure 3.1
Respiration Test
Oxygen and Helium Concentrations
Site 27, VW
Nellis AFB, Nevada

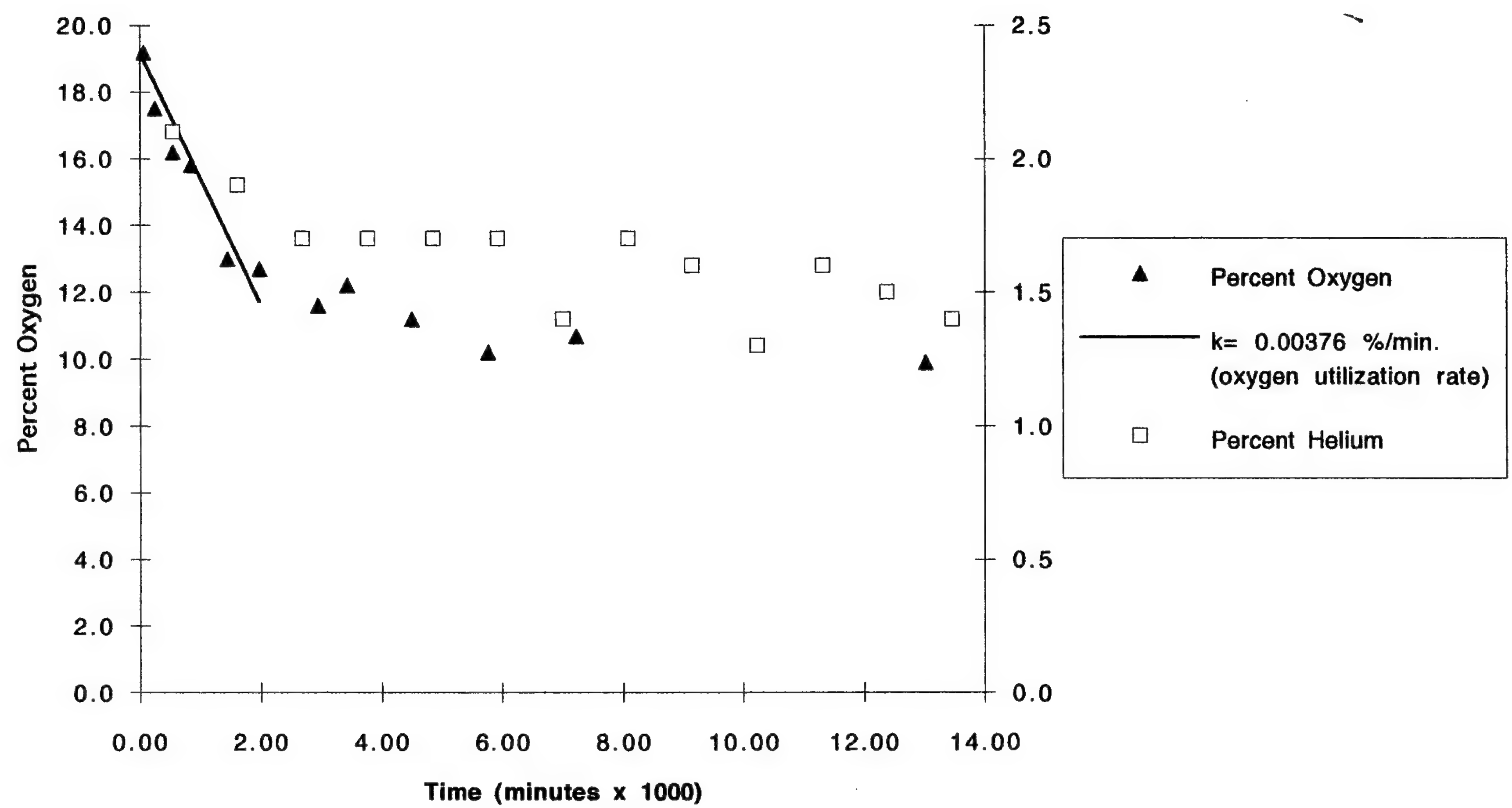


Figure 3.2
Respiration Test
Oxygen and Helium Concentrations
Site 27, MPA-70
Nellis AFB, Nevada

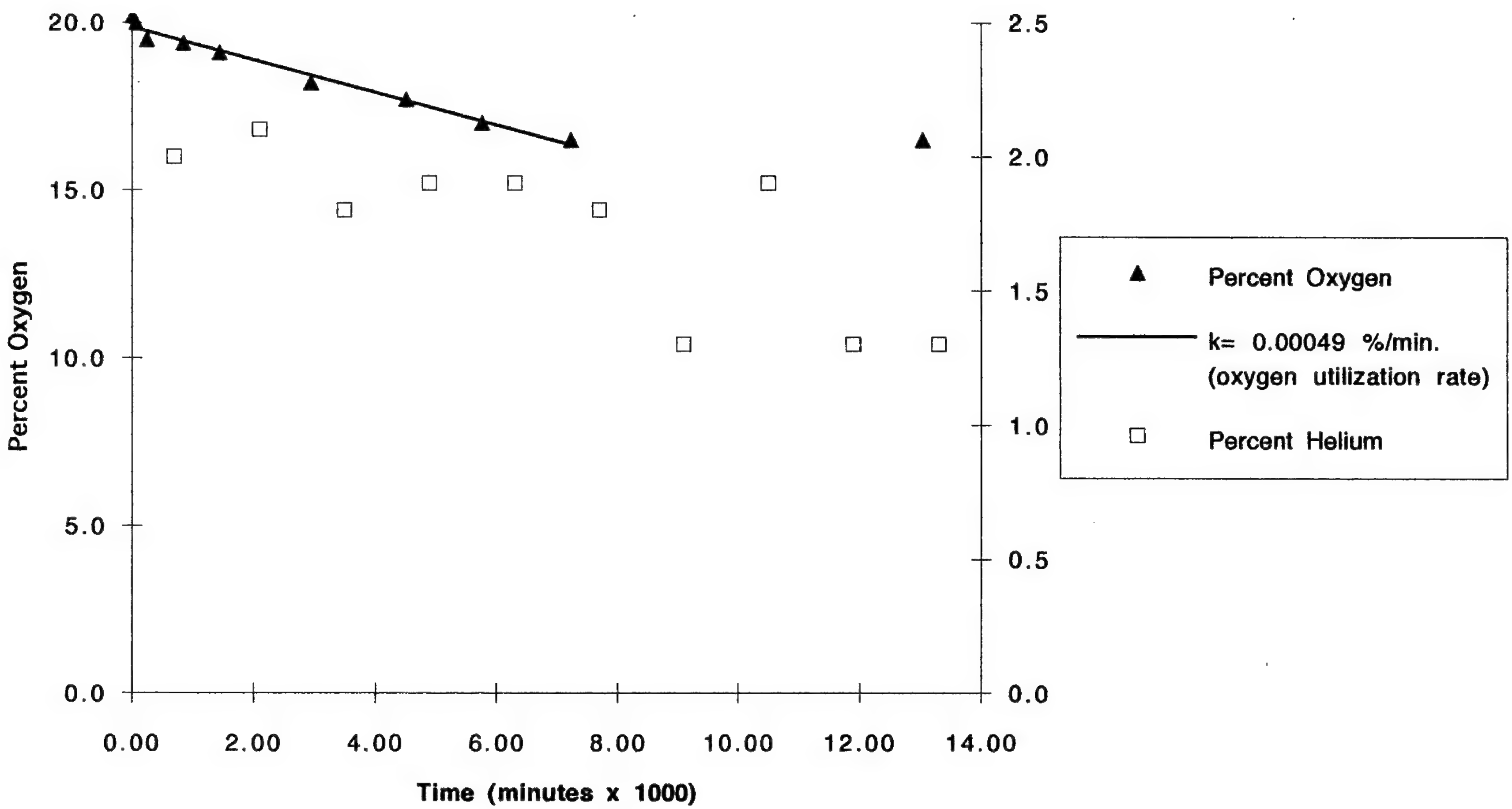


Figure 3.3
Respiration Test
Oxygen and Helium Concentrations
Site 27, MPB-55
Nellis AFB, Nevada

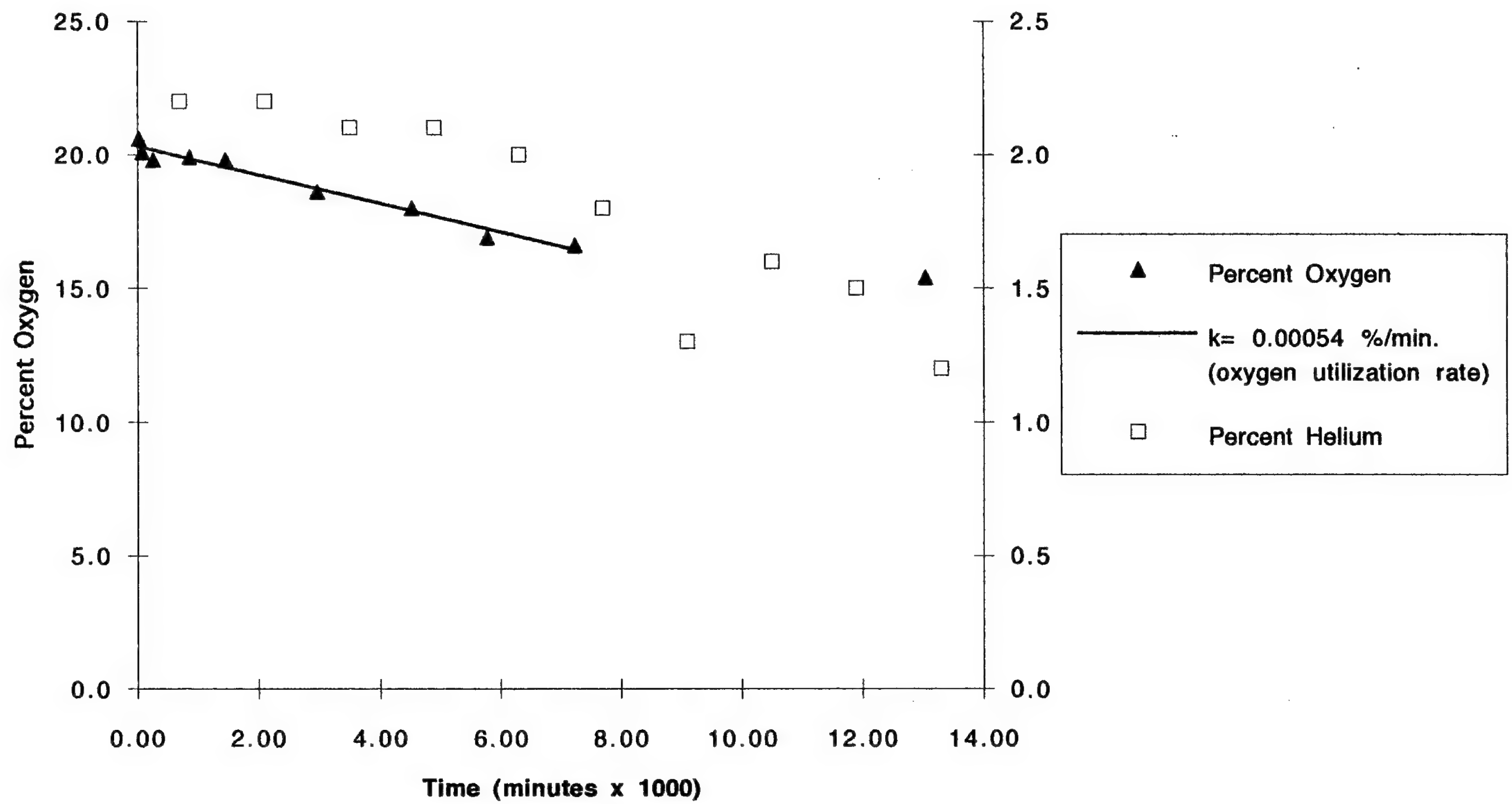


Figure 3.4
Respiration Test
Oxygen and Helium Concentrations
Site 27, MPC-55
Nellis AFB, Nevada

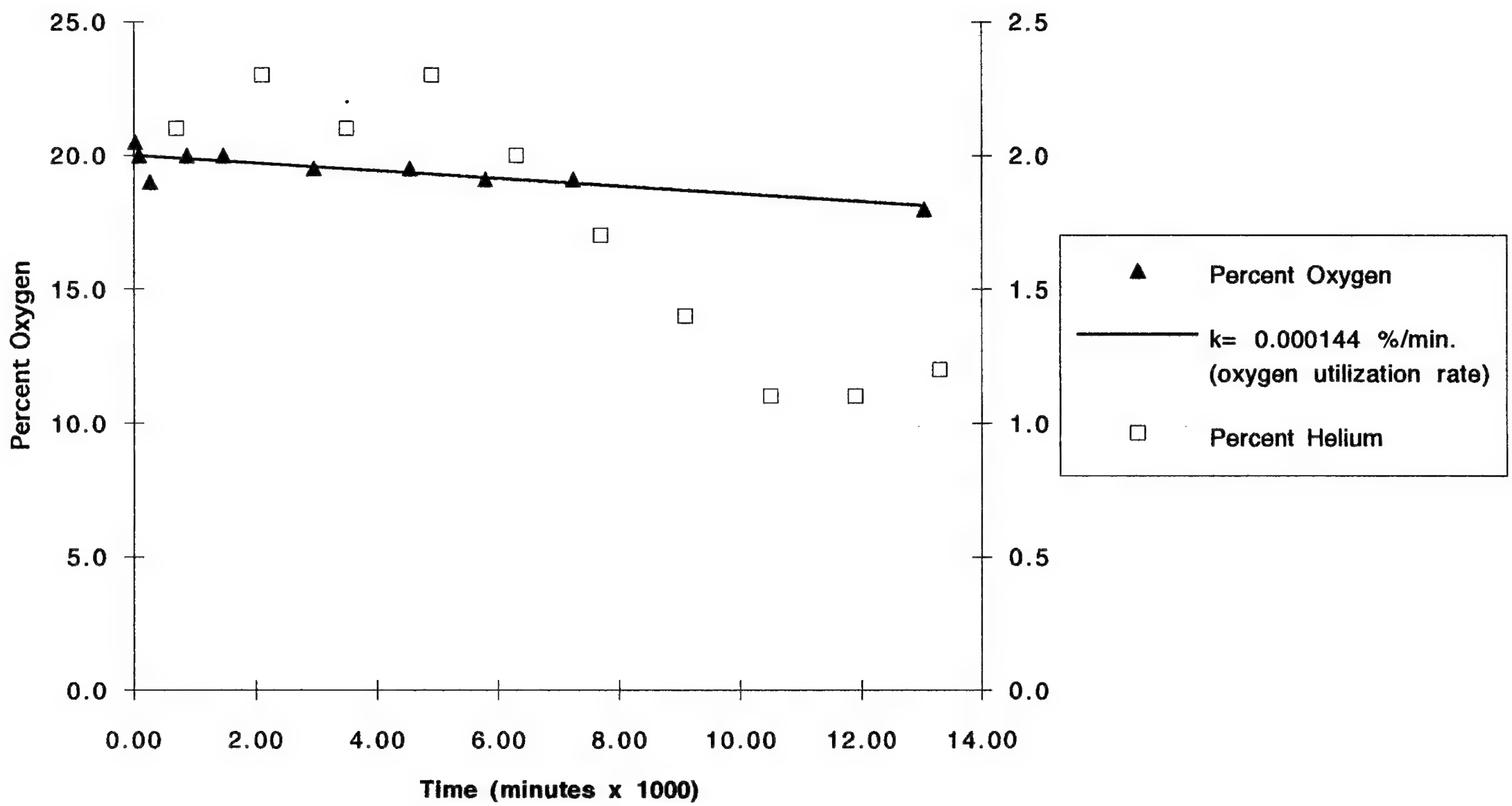


TABLE 3.4

OXYGEN UTILIZATION RATES
SITE 27
NELLIS AFB, NEVADA

Location	O_2 Loss[a/] (%)	Test[b/] Duration (min)	O_2 Utilization[c/] Rate (%/min)
MPA-70	3.7	7,220	0.0005
MPB-55	4.0	7,230	0.0005
MPC-55	2.5	13,050	0.0001
VW	7.9	1,980	0.0038

a/ Actual measured oxygen loss.

b/ Elapsed time from beginning of test to time when minimum oxygen concentration was measured.

c/ Values based on best-fit lines (Figures 3.1 through 3.4).

TABLE 3.5

INITIAL SOIL GAS CHEMISTRY
SITE 28
NELLIS AFB, NEVADA

Sample Location	Depth (ft)	O_2 (%)	CO_2 (%)	Field TVH (ppmv)[a/]	Lab TVH (ppmv)[b/]	Soil TRPH (mg/kg)[c/]
MPA	30	0.5	15.3	15,400	NS[d/]	NS
MPB	30	1.0	15.0	16,400	NS	ND[e/]
MPC	30	0.8	14.2	13,800	38,000	NS
MPA	40	0.5	13.9	>20,000	NS	NS
MPB	40	1.0	14.5	>20,000	NS	NS
MPC	40	1.0	14.0	>20,000	NS	NS
MPA	50	0.0	2.5	>20,000	80,000	NS
MPB	50	---[f/]	---	---	---	8,720
MPC	50	0.7	14.0	>20,000	NS	NS
MPA	60	---	---	---	---	NS
MPB	60	2.2	8.2	>20,000	NS	NS
VW	55-80	1.2	14.0	>20,000	98,000	196[g/]

a/ Field screening results, in parts per million, volume per volume (ppmv).

b/ Laboratory results.

c/ Laboratory soil results, in milligrams per kilogram (mg/kg).

d/ NS = not sampled.

e/ ND = not detected.

f/ --- = unable to collect sample due to tight soil conditions.

g/ Sample collected from 65 feet bgs.

TABLE 3.6

MAXIMUM PRESSURE RESPONSE
AIR PERMEABILITY TEST
SITE 28
NELLIS AFB, NEVADA

	Distance from VW (feet)										
	15 (MPA)				29 (MPB)				56 (MPC)		
Depth (feet)	30	40	50	60	30	40	50	60	30	40	50
Time (min)	90	90	120	110	90	90	150	150	100	70	110
Max Press. (inches H_2O)	0.40	0.90	1.80	36.5	0.24	0.50	0.00	28.4	0.16	0.25	0.54

3.2.3 Oxygen Influence

The depth and radius of oxygen increase in the subsurface resulting from air injection into the central VW during pilot testing is the primary design parameter for full-scale bioventing systems. Optimization of full-scale and multiple VW systems requires pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 3.7 presents the change in soil gas oxygen levels that occurred during the 18-hour air permeability test. This period of air injection at approximately 27 scfm produced changes in soil gas oxygen levels at each of the functioning MP screened intervals. Based on measured changes in oxygen levels, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 55 feet at all depths between the groundwater surface and approximate 30 feet bgs. Monitoring during the extended pilot test at this site will better define the effective treatment radius.

3.2.4 *In Situ* Respiration Rates

The *in situ* respiration test was performed by injecting a mixture of air (oxygen) and approximately 2.2 percent helium (inert tracer gas) into three MP screened intervals (MPA-50, MPB-60, and MPC-40) and the VW for a 22-hour period. Oxygen loss and other changes in soil gas composition over time were then measured at these intervals and at all other MP intervals which had elevated oxygen levels following the air injection. Oxygen, TVH, carbon dioxide, and helium were measured for a period of approximately 3.6 days following air injection. The measured oxygen losses were then used to calculate biological oxygen utilization rates. The results of *in situ* respiration testing for the MP intervals at this site are presented in Figures 3.5 through 3.8. Additional respiration test results are included in Appendix A. Table 3.8 provides a summary of the oxygen utilization rates.

Because helium is a conservative, inert gas, the change in helium concentrations over time can be useful in determining the effectiveness of the bentonite seals between MP screened intervals. Figures 3.5 through 3.8 compare oxygen utilization and helium retention. Because the observed helium loss was negligible, and because helium will diffuse approximately three times faster than oxygen due to oxygen's greater molecular weight, the measured oxygen loss is the result of bacterial respiration and is not due to faulty MP construction.

Oxygen loss occurred at moderate rates, ranging from 0.0009 percent per minute at MPC-40 to 0.0046 percent per minute at MPA-50. At MPA-50, oxygen dropped from 20.0 percent to 4.9 percent in 3,410 minutes.

Based on these oxygen utilization rates, an estimated 70 to 1,220 mg of fuel per kg of soil can be degraded each year at this site. This conservative estimate is based on an average air-filled porosity of approximately 0.08 liter per kg of soil, and a ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded.

3.2.5 Potential Air Emissions

The long-term potential for air emissions from full-scale bioventing operations at this site is low because of the air injection depth. Accumulated vapors will move slowly outward from the air injection VW, and vapor-phase hydrocarbons will be biodegraded as they move horizontally through the soil. Health and safety readings were taken inside Building 947

TABLE 3.7

INFLUENCE OF AIR INJECTION AT VENT WELL ON MONITORING POINT OXYGEN LEVELS SITE 28 NELLIS AFB, NEVADA

MP	Distance From VW (ft)	Depth (ft)	Inital O_2 (%)	Final O_2 (%)[a/]
A	15	30	0.5	7.0
B	29	30	1.0	1.0
C	56	30	0.8	0.8
A	15	40	0.5	20.2
B	29	40	1.0	19.4
C	56	40	1.0	14.1
A	15	50	0.0	5.5
B	29	50	---[b/]	20.4
C	56	50	0.7	17.4
A	15	60	---	19.7
B	29	60	2.2	17.9

a/ Reading taken at end of 18-hour air permeability test.

b/ --- = unable to collect sample due to tight soil conditions.

Figure 3.5
Respiration Test
Oxygen and Helium Concentrations
Site 28, VW
Nellis AFB, Nevada

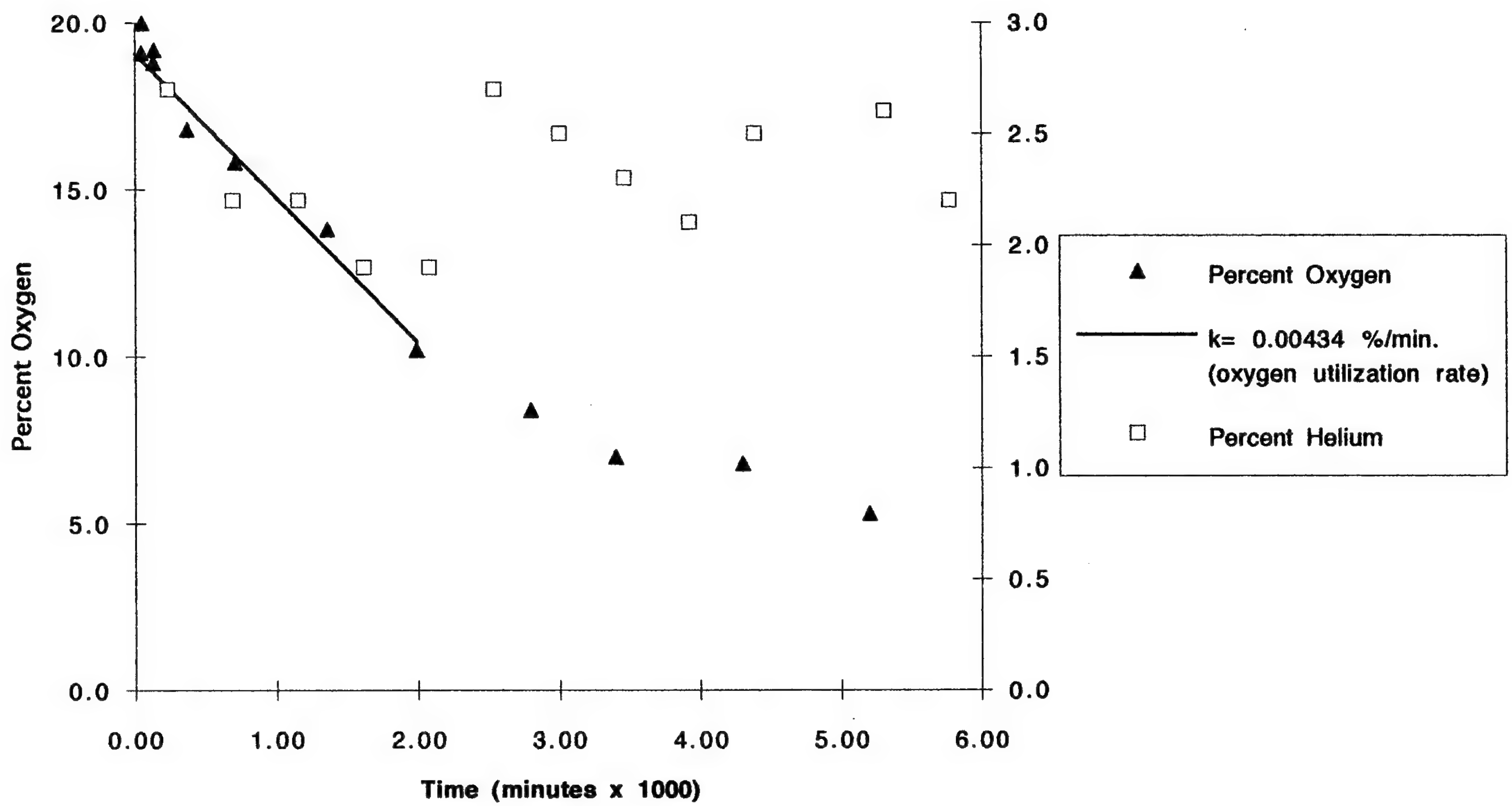


Figure 3.6
Respiration Test
Oxygen and Helium Concentrations
Site 28, MPA-50
Nellis AFB, Nevada

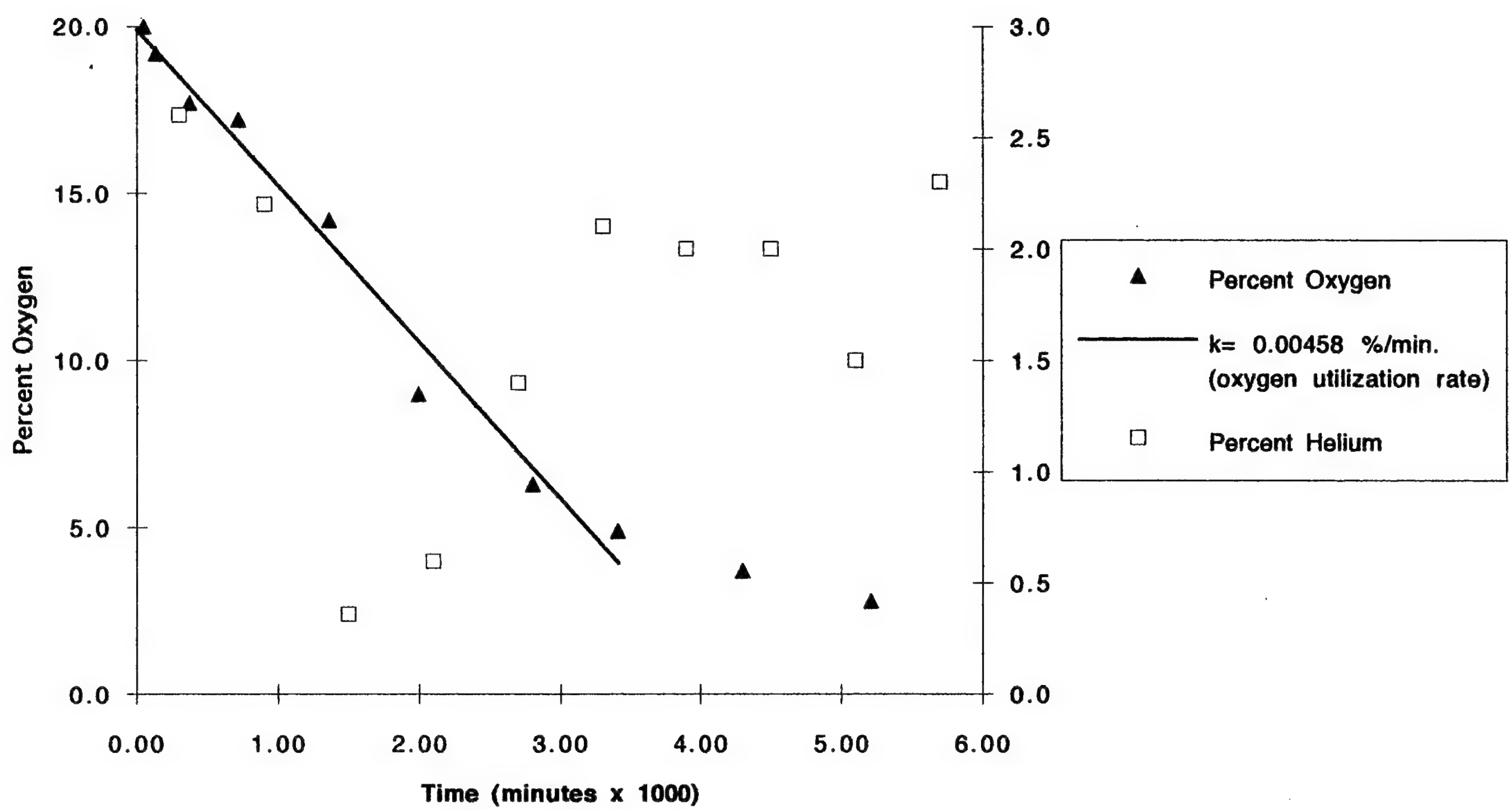


Figure 3.7
Respiration Test
Oxygen and Helium Concentrations
Site 28, MPB-60
Nellis AFB, Nevada

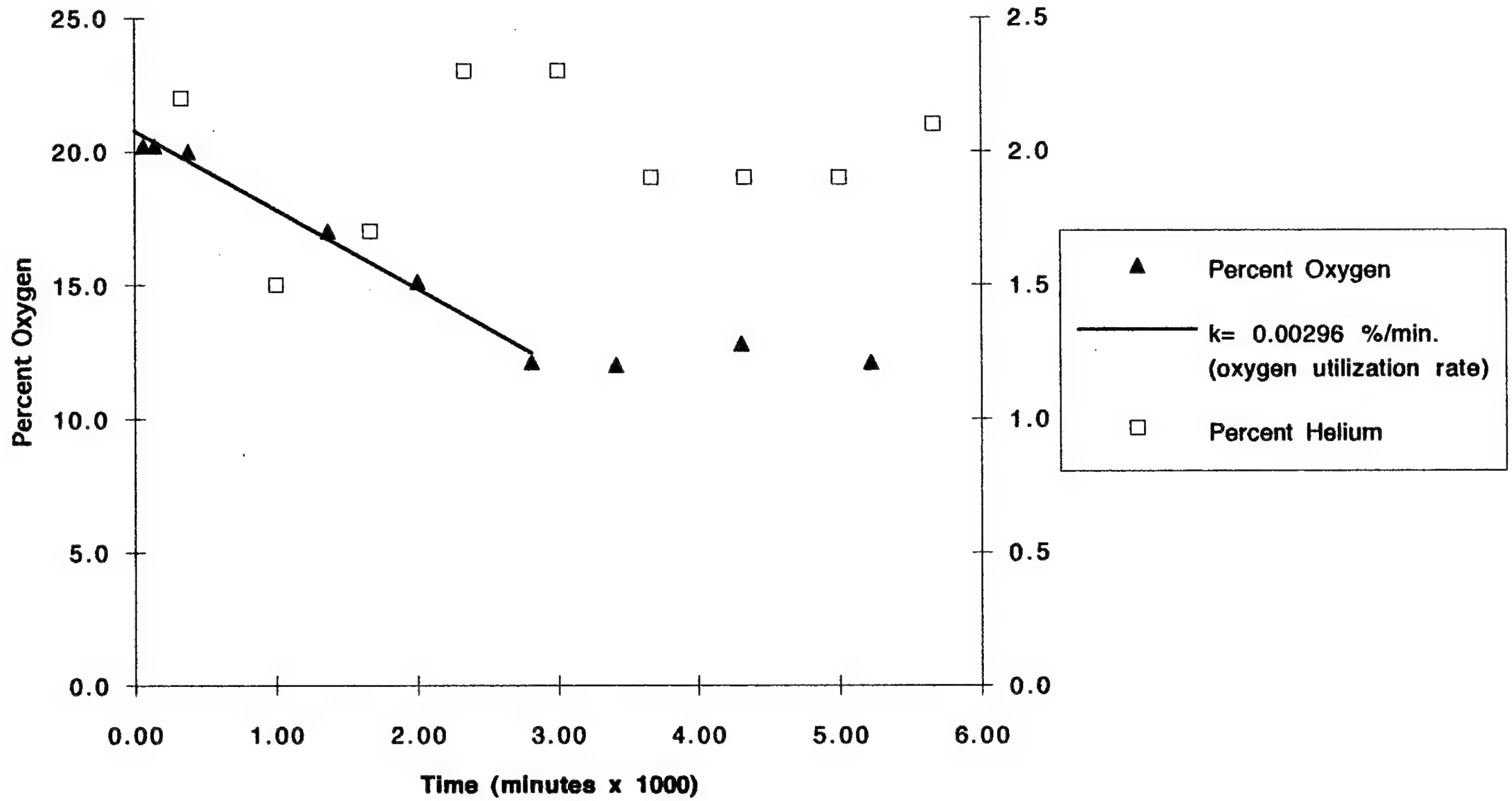


TABLE 3.8

OXYGEN UTILIZATION RATES
SITE 28
NELLIS AFB, NEVADA

Location	O_2 Loss[a/] (%)	Test[b/] Duration (min)	O_2 Utilization[c/] Rate (%/min)
MPA-50	15.1	3,410	0.0046
MPB-60	8.1	2,810	0.0030
MPC-40	4.6	5,220	0.0009
VW	8.9	1,990	0.0043

a/ Actual measured oxygen loss.

b/ Elapsed time from beginning of test to time when minimum oxygen concentration was measured.

c/ Values based on best-fit lines (Figures 3.5 through 3.8).

prior to leaving the site to ensure that no vapors were migrating into the building as a result of air injection at the site. All readings inside and beneath the building were at background levels.

3.3 Site 44

3.3.1 Initial Soil Gas Chemistry

Prior to initiating any air injection, all MPs and the VW were purged until oxygen levels had stabilized, and initial oxygen, carbon dioxide, and TVH concentrations were sampled using portable gas analyzers as described in the protocol document (Hinchee et al., 1992). At all MP screened intervals sampled, microorganisms had significantly depleted soil gas oxygen supplies, indicating significant biological activity and soil contamination. Table 3.9 summarizes the initial soil gas chemistry.

3.3.2 Air Permeability

An air permeability test was conducted according to protocol document procedures. Air was injected into the VW for 27 hours at a rate of approximately 48 scfm and an average pressure of 1.5 psi. The maximum pressure response at each MP is listed in Table 3.10. The pressure measured at the MPs quickly increased at a regular rate throughout the period of air injection. Due to the short-term pressure response, the steady-state method of determining air permeability was selected. A soil gas permeability value of 2.9 darcys, typical for clay soils, was calculated for this site. A radius of pressure influence of at least 35 feet was observed at all depths.

3.3.3 Oxygen Influence

The depth and radius of oxygen increase in the subsurface resulting from air injection into the central VW during pilot testing is the primary design parameter for full-scale bioventing systems. Optimization of full-scale and multiple VW systems requires pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 3.11 presents the change in soil gas oxygen levels that occurred during the 27-hour air permeability test. Since the permeability test was conducted with the same blower that will be used for the 1-year extended pilot tests, these oxygen influence results are indicative of what the long-term results will be. This period of air injection at approximately 48 scfm produced changes in soil gas oxygen levels at all of the functioning MP screened intervals. Based on measured changes in oxygen levels, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 35 feet at all depths. Monitoring during the extended pilot test at this site will better define the effective treatment radius.

3.3.4 *In Situ* Respiration Rates

The *in situ* respiration test was performed by injecting a mixture of air (oxygen) and approximately 2.8 percent helium (inert tracer gas) into three MP screened intervals (MPA-32, MPB-39, and MPC-24) and the VW for a 19-hour period. Oxygen loss and other changes in soil gas composition over time were then measured at these intervals and at all other MP intervals which had elevated oxygen levels following the air injection. Oxygen, TVH,

TABLE 3.9

INITIAL SOIL GAS CHEMISTRY
SITE 44
NELLIS AFB, NEVADA

Sample Location	Depth (ft)	O_2 (%)	CO_2 (%)	Field TVH (ppmv)[a/]	Lab TVH (ppmv)[b/]	Soil TRPH (mg/kg)[c/]
MPA	24	0.0	15.5	6,000	NS[d/]	NS
MPB	24	0.5	15.0	7,200	NS	25.3
MPC	24	0.8	13.5	10,400	NS	NS
MPA	32	0.0	16.9	12,400	23,000	865
MPB	32	0.5	13.8	16,200	NS	NS
MPC	32	1.0	10.0	>20,000	NS	NS
MPA	39	---[e/]	---	---	---	NS
MPB	39	0.5	3.7	>20,000	NS	NS
MPC	39	0.5	1.4	>20,000	45,000	NS
VW	18-43	1.2	15.9	11,600	20,000	ND[f/ g/]

a/ Field screening results, in parts per million, volume per volume (ppmv).

b/ Laboratory results.

c/ Laboratory soil results, in milligrams per kilogram (mg/kg).

d/ NS = not sampled.

e/ --- = unable to collect sample due to tight soil conditions.

f/ ND = not detected.

g/ Sample collected from 40 feet bgs.

TABLE 3.10

MAXIMUM PRESSURE RESPONSE
AIR PERMEABILITY TEST
SITE 44
NELLIS AFB, NEVADA

	Distance from VW (feet)								
	10 (MPA)			20 (MPB)			35 (MPC)		
Depth (feet)	24	32	39	24	32	39	24	32	39
Time (min)	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
Max Press. (inches H_2O)	1.20	1.55	2.25	0.85	1.15	1.35	0.50	0.65	0.73

TABLE 3.11

INFLUENCE OF AIR INJECTION AT VENT WELL ON MONITORING POINT OXYGEN LEVELS SITE 44 NELLIS AFB, NEVADA

MP	Distance From VW (ft)	Depth (ft)	Inital O_2 (%)	Final O_2 (%)[a/]
A	10	24	0.0	18.3
B	20	24	0.5	3.9
C	35	24	0.8	15.5
A	10	32	0.0	20.2
B	20	32	0.5	19.4
C	35	32	1.0	3.1
A	10	39	---[b/]	---
B	20	39	0.5	19.9
C	35	39	0.5	0.9

a/ Reading taken after approximately 27 hours of injection using long-term blower system.

b/ --- = unable to collect sample due to tight soil conditions.

carbon dioxide, and helium were measured for a period of approximately 3 days following air injection. The measured oxygen losses were then used to calculate biological oxygen utilization rates. The results of *in situ* respiration testing for the MP intervals at this site are presented in Figures 3.9 through 3.12. Additional respiration test results are included in Appendix A. Table 3.12 provides a summary of the oxygen utilization rates.

Because helium is a conservative, inert gas, the change in helium concentrations over time can be useful in determining the effectiveness of the bentonite seals between MP screened intervals. Figures 3.9 through 3.12 compare oxygen utilization and helium retention. Because the observed helium loss was negligible, and because helium will diffuse approximately three times faster than oxygen due to oxygen's greater molecular weight, the measured oxygen loss is the result of bacterial respiration and not due to faulty MP construction.

Oxygen loss occurred at moderate to rapid rates, ranging from 0.0050 percent per minute at MPA-32 to 0.0221 percent per minute at MPB-39. At MPB-39, oxygen dropped from 18.3 percent to 7.3 percent in 600 minutes.

Based on these oxygen utilization rates, an estimated 470 to 6,200 milligrams (mg) of fuel per kilogram (kg) of soil can be degraded each year at this site. This conservative estimate is based on an average air-filled porosity of approximately 0.10 liter per kg of soil, and a ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. If oxygen can be uniformly distributed in these soils, excellent long-term remediation is predicted.

3.3.5 Potential Air Emissions

The long-term potential for air emissions from full-scale bioventing operations at this site is low because of the air injection depth and the relatively impermeable asphalt and concrete covering the surface of the site. Accumulated vapors will move slowly outward from the air injection VW, and vapor-phase hydrocarbons will be biodegraded as they move horizontally through the soil.

4.0 RECOMMENDATIONS

4.1 Site 27

Initial bioventing tests at this site indicate that oxygen has been depleted in the contaminated soils, and that air injection is an effective method of increasing aerobic fuel biodegradation. Although initial biodegradation rates at the site are relatively slow, AFCEE has recommended that air injection continue at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing temperatures on fuel biodegradation rates.

A small, 1-horsepower regenerative blower has been installed at the site to continue air injection at a rate of approximately 40 scfm. The electrical work was completed, and the blower system was started on February 8, 1994. In August 1994, ES will return to the site to sample and analyze the soil gas and conduct a repeat respiration test. In February 1995, a final respiration test will be conducted, and soil and soil gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

Figure 3.9
Respiration Test
Oxygen and Helium Concentrations
Site 44, VW
Nellis AFB, Nevada

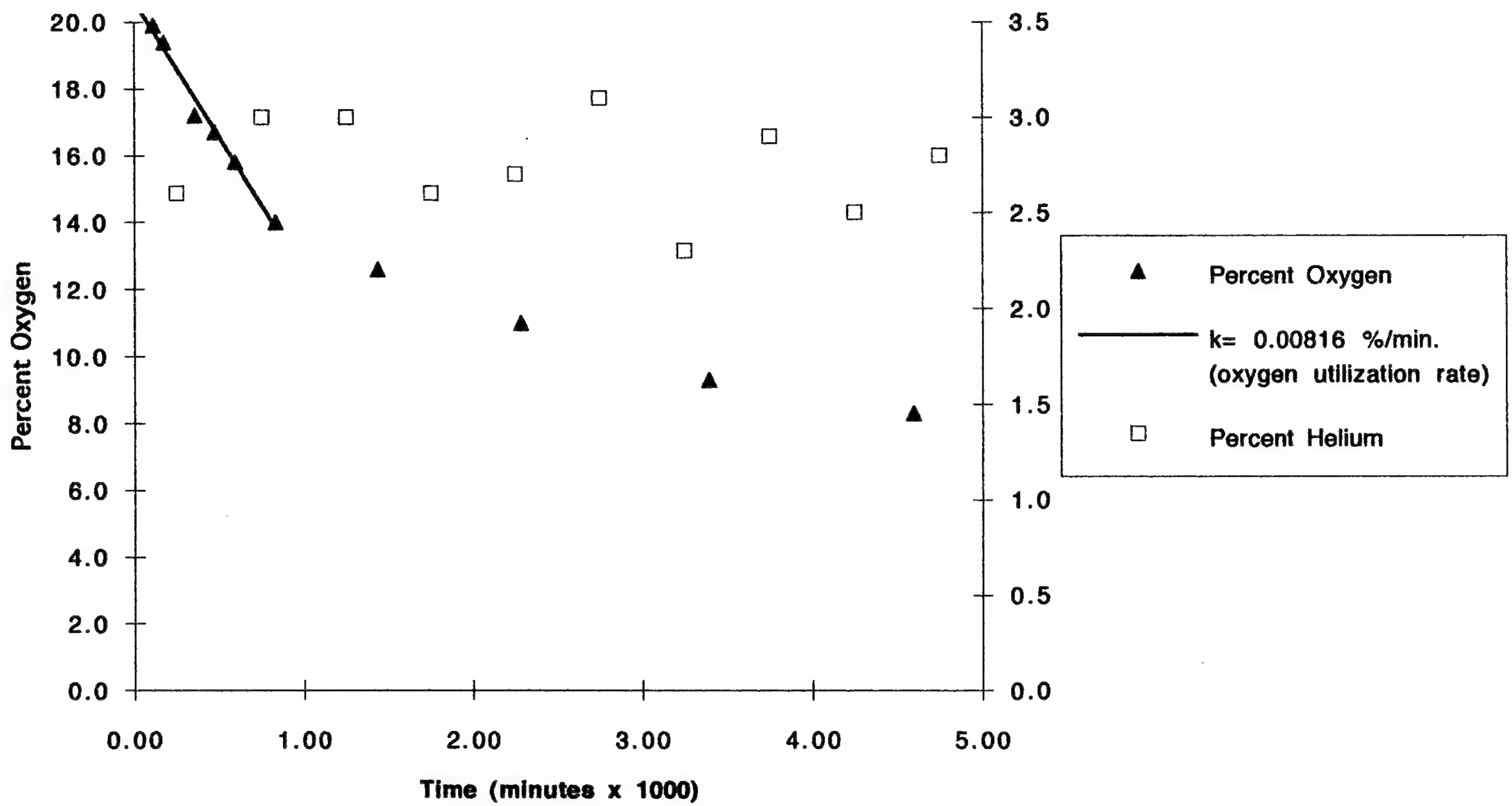


Figure 3.10
Respiration Test
Oxygen and Helium Concentrations
Site 44, MPA-32
Nellis AFB, Nevada

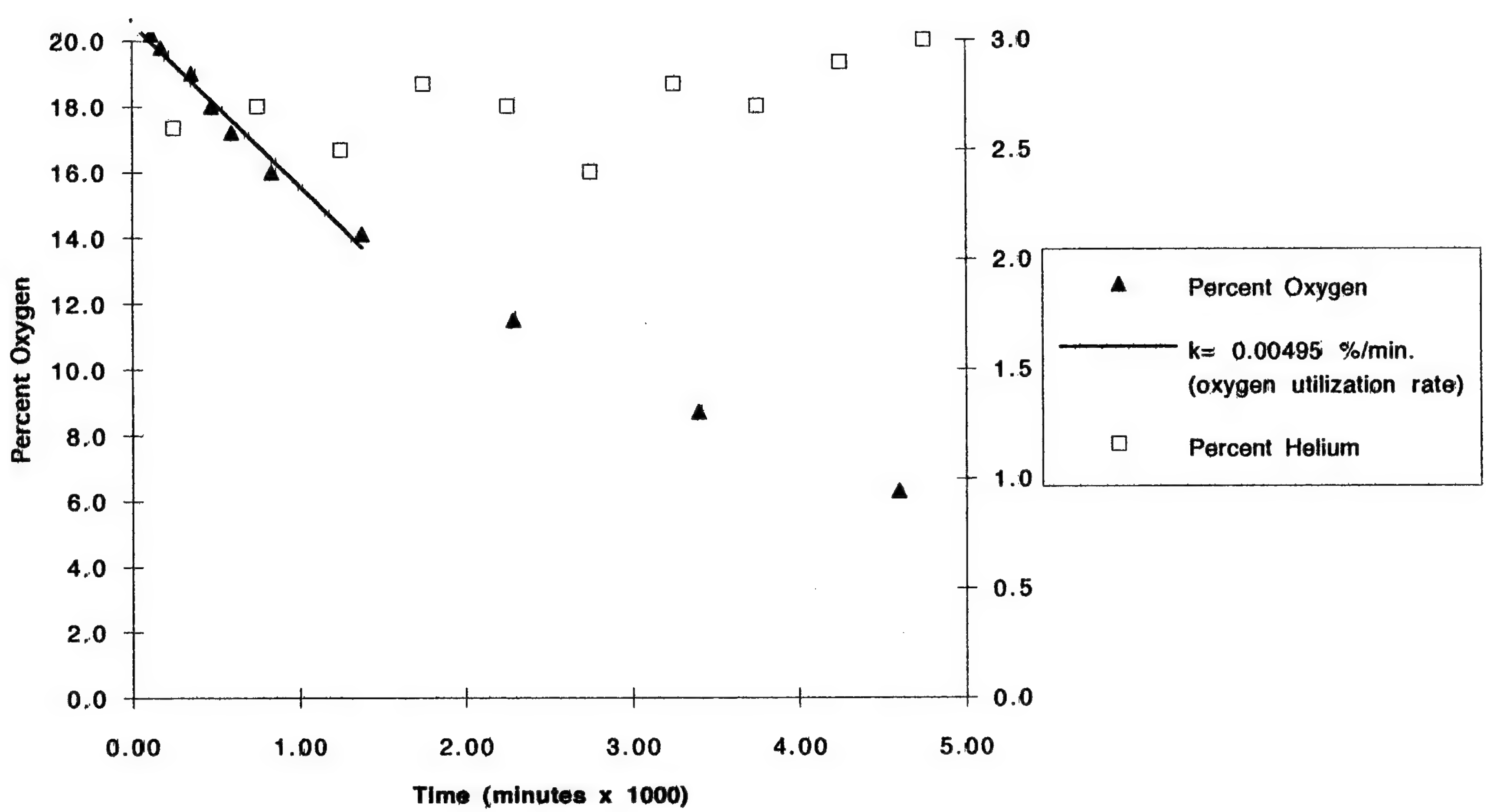


TABLE 3.12

OXYGEN UTILIZATION RATES
SITE 44
NELLIS AFB, NEVADA

Location	O_2 Loss[a/] (%)	Test[b/] Duration (min)	O_2 Utilization[c/] Rate (%/min)
MPA-32	6.1	1,380	0.0050
MPB-39	11.0	600	0.0221
MPC-24	10.0	610	0.0204
VW	5.9	830	0.0082

a/ Actual measured oxygen loss.

b/ Elapsed time from beginning of test to time when minimum oxygen concentration was measured.

c/ Values based on best-fit lines (Figures 3.9 through 3.12).

Based on the results of the first year of pilot-scale bioventing, AFCEE will recommend one of three options:

- Upgrade, if necessary, and continue operation of the bioventing system for full-scale remediation of the site. AFCEE can assist the Base in obtaining regulatory approval for upgrading and continued operation; or
- If final soil sampling indicates significant contaminant removal has occurred, AFCEE may recommend additional sampling to confirm that cleanup criteria have been achieved; or
- If significant difficulties or poor results are encountered during bioventing at this site, AFCEE may recommend removal of the blower system and proper abandonment of the VW and MPs.

4.2 Site 28

Initial bioventing tests at this site indicate that oxygen has been depleted in the contaminated soils, and that air injection is an effective method of increasing aerobic fuel biodegradation. AFCEE has recommended that air injection continue at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing temperatures on fuel biodegradation rates.

A small, 1-horsepower regenerative blower has been installed at the site to continue air injection at a rate of approximately 52 scfm. The electrical work was completed, and the blower system was started on February 8, 1994. In August 1994, ES will return to the site to sample and analyze the soil gas and conduct a repeat respiration test. In February 1995, a final respiration test will be conducted, and soil and soil gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

Based on the results of the first year of pilot-scale bioventing, AFCEE will recommend one of three options:

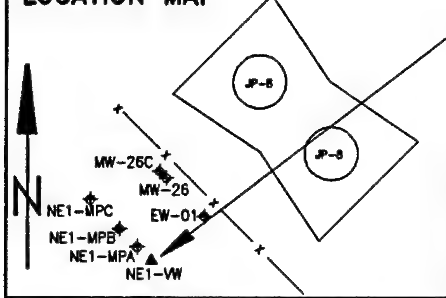
- Upgrade, if necessary, and continue operation of the bioventing system for full-scale remediation of the site. AFCEE can assist the Base in obtaining regulatory approval for upgrading and continued operation; or
- If final soil sampling indicates significant contaminant removal has occurred, AFCEE may recommend additional sampling to confirm that cleanup criteria have been achieved; or
- If significant difficulties or poor results are encountered during bioventing at this site, AFCEE may recommend removal of the blower system and proper abandonment of the VW and MPs.

4.3 Site 44

Initial bioventing tests at this site indicate that oxygen has been depleted in the contaminated soils, and that air injection is an effective method of increasing aerobic fuel biodegradation. AFCEE has recommended that air injection continue at this site to determine the long-term radius of oxygen influence and the effect of time, available nutrients, and changing temperatures on fuel biodegradation rates.

APPENDIX A
GEOLOGIC BORING LOGS,
CHAIN-OF-CUSTODY FORMS,
TEST DATA, AND CALCULATIONS

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

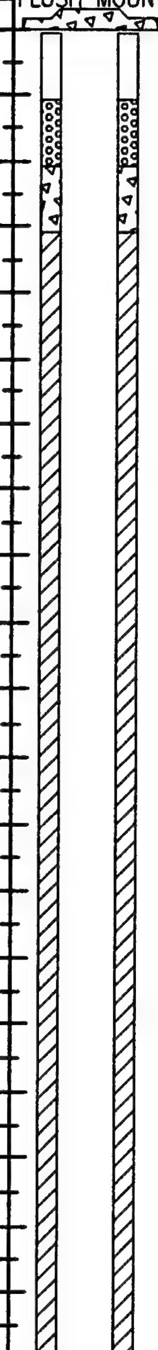
WELL NUMBER	NE1-VW	LOCATION	35' SW of Tank Farm Fence
DATE	1-13-94	WEATHER	Clear, Calm 38°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	6-5/8" ID Hollow-stem Auger	SAMPLING METHOD	0' -40' 1.5" S/S 40'-80' 2.0" S/S
GRAVEL PACK	Colorado Silica Sand #6-9 80'-52'	SEAL	Holeplug 47'-3' 1/4" Bentonite 52'-47'

CASING	TYPE Schedule 40 PVC	DIAMETER 4"	LENGTH 54'	HOLE DIA. 11"
SCREEN	TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 4"	LENGTH 25"	TOTAL DEPTH 80'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
						0			Pilot hole with 4-1/4" ID HSA Overdrill with 8-5/8" ID HSA
dry	poor	stiff	plas			5			Cuttings – SILT AND CLAY, light brown, little fine-grained sand. (CL)
dry	poor	v stiff	v plas			10	1.00	17 40 50=2"	0.00'-1.00' CLAY, light brown, some silt, trace of very fine-grained sand, partially cemented. (CH)
						15			Cuttings – Same as above.
						20			

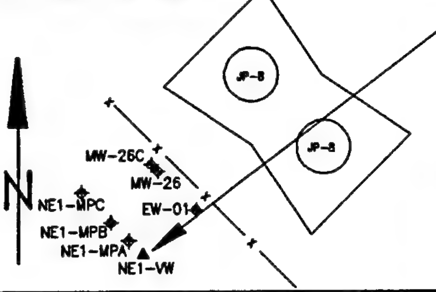
WELL COMPLETION

FLUSH MOUNT



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

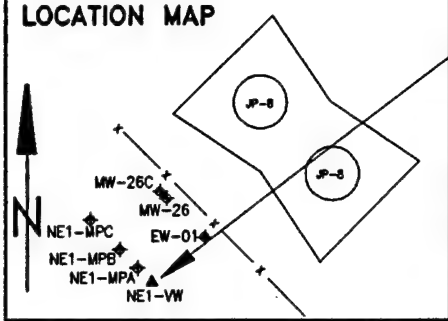
WELL NUMBER	NE1-VW	LOCATION	35' SW of Tank Farm Fence
DATE	1-13-94	WEATHER	Clear, Calm 38°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	6-5/8" ID Hollow-stem Auger	SAMPLING METHOD	0' -40' 1.5" S/S 40'-80' 2.0" S/S
GRAVEL PACK	Colorado Silica Sand #6-9 80'-52'	SEAL	Holeplug 47'-3' 1/4" Bentonite 52'-47'

CASING	TYPE Schedule 40 PVC		DIAMETER 4"	LENGTH 54'	HOLE DIA. 11"
SCREEN	TYPE Sch 40 PVC	SLOT 0.040"	DIAMETER 4"	LENGTH 25"	TOTAL DEPTH 80'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS		WELL COMPLETION
dry	poor	hard	x hard			20	0.94	50=1"	0.00'-0.94'	CLAY, as above. Little amount of caliche gravel. (CH)	
						21		–			
						22					
						23			21'-23'	CALICHE, Hard Drilling.	
						24					
						25					
						26					
						27					
						28					
						29					
damp		m stiff	plas			30	1.18	7 12 13	0.00'-1.18'	CLAY, light yellowish brown, some silt, trace of very fine-grained sand. (CL)	
						31					
						32					
						33					
						34					
						35			Cuttings –	Same as above.	
						36					
						37					
						38					
						39					
						40					

EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



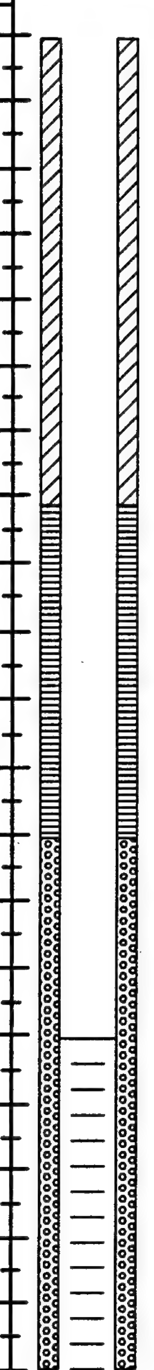
WELL NUMBER	NE1-VW	LOCATION	35' SW of Tank Farm Fence
DATE	1-13-94	WEATHER	Clear, Calm 38°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	6-5/8" ID Hollow-stem Auger	SAMPLING METHOD	0' -40' 1.5" S/S 40'-80' 2.0" S/S
GRAVEL PACK	Colorado Silica Sand #6-9 80'-52'	SEAL	Holeplug 47'-3' 1/4" Bentonite 52'-47'

CASING ▶ TYPE Schedule 40 PVC DIAMETER 4" LENGTH 54' HOLE DIA. 11"

SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040" DIAMETER 4" LENGTH 25" TOTAL DEPTH 80'

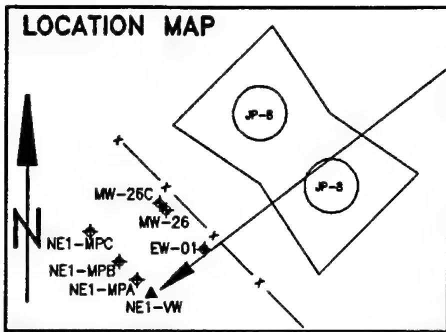
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
damp		m stiff	plas			40	1.34	9, 9, 15	0.00'-1.34' CLAY, as above. Little dark mottling. (CL)
						41			
						42			
						43			
						44			
damp	poor	m dens	sl plas -non		25	45	1.31	12, 15, 20	0.00'-1.31' SAND, light yellowish brown, fine-grained, little clay and silt, hydrocarbon odor. (ML)
						46			
						47			
						48			
						49			
damp		v stiff	plas	NE1-VW-50	48	50	1.50	30, 30, 50=2"	0.00'-1.50' CLAY, light yellowish brown, little silt, trace of very fine-grained sand. (CH)
						51			
						52			
						53			
						54			
damp		m stiff	plas	NE1-VW-55		55		36, 15, 19	0.00'-1.50' CLAY, same as above.
						56			
						57			
						58			
						59			
						60			

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

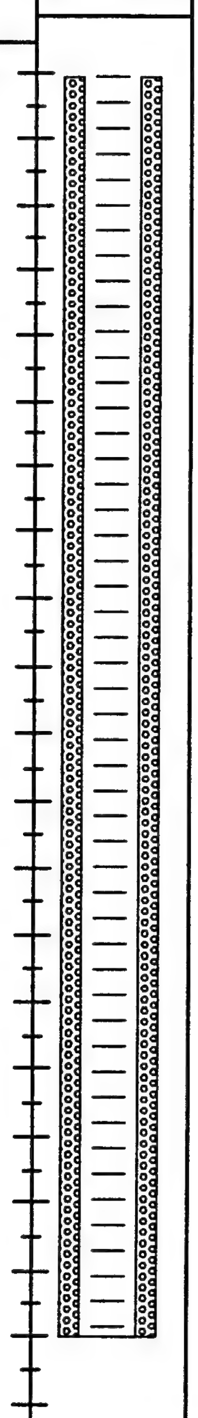
WELL NUMBER	NE1-VW	LOCATION	35' SW of Tank Farm Fence
DATE	1-13-94	WEATHER	Clear, Calm 38°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	6-5/8" ID Hollow-stem Auger	SAMPLING METHOD	0' -40' 1.5" S/S; 40'-80' 2.0" S/S
GRAVEL PACK	Colorado Silica Sand #6-9 80'-52'	SEAL	Holeplug 47'-3'; 1/4" Bentonite 52'-47'

CASING ▶ TYPE Schedule 40 PVC DIAMETER 4" LENGTH 54' HOLE DIA. 11"

SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040" DIAMETER 4" LENGTH 25" TOTAL DEPTH 80'

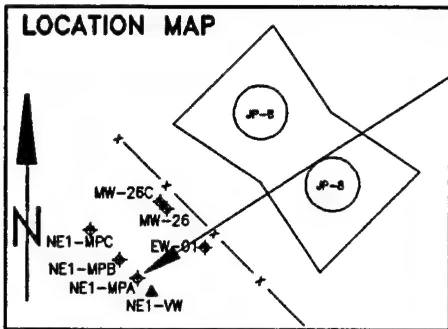
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
damp		m stiff	plas	NE1-VW-60	14	60	1.50	13 / 23 / 50=.5"	0.00'-1.50' CLAY, as above. Some caliche pebbles and gravel. (CL)
						61–64			
damp		stiff	plas	NE1-VW-65	1200	65	1.50	10 / 10 / 23	0.00'-1.50' CLAY, as above.
						66–69			
damp		stiff	plas	NE1-VW-70	NA	70	1.50	23 / 30 / 49	0.00'-1.50' CLAY, as above.
						71–74			
damp		stiff	plas	NE1-VW-75	5000	75	1.50	20 / 20 / 17	0.00'-1.50' CLAY, as above.
						76–78			
moist		stiff	plas	NE1-VW-80	4000	79	1.50	15 / 18 / 25	0.00'-1.00' CLAY, as above.
wet-sat		soft	sl plas						1.00'-1.50' CLAY, light yellowish brown, some silt and fine caliche gravel, hydrocarbon odor. (CL)
						80			

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

WELL NUMBER	NE1-MPA	LOCATION	35' SW of Tank Farm Fence
DATE	1-14-94	WEATHER	Clear, Calm 40°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -65' 1.5" S/S 65'-75' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

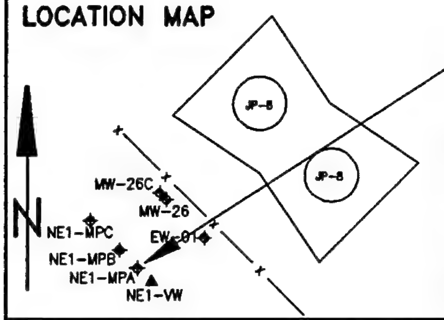
CASING ▶ TYPE 0.25" ID PVC DIAMETER 0.5" LENGTH 55', 65' & 70' HOLE DIA. 8"

SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040" DIAMETER 1" LENGTH 6" TOTAL DEPTH 70'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	WELL COMPLETION
						0				FLUSH MOUNT
dry	poor	dense	non			5			Cuttings - SAND, light brown, some clay, very fine and fine-grained, little gravel, loose and dry. (ML)	
dry	poor	dense	non			10	0.89	19 50=5" -	0.00'-0.89' CLAY, SILT, SAND AND CALICHE GRAVEL, light brown, some limestone cobbles. (GC)	
dry		stiff	plas			15			Cuttings - SILT AND CLAY, light brown.	
						17			17'-22' CALICHE, Hard Drilling.	
						20				

EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

WELL NUMBER	NE1-MPA	LOCATION	35' SW of Tank Farm Fence
DATE	1-14-94	WEATHER	Clear, Calm 40°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -65' 1.5" S/S; 65'-75' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

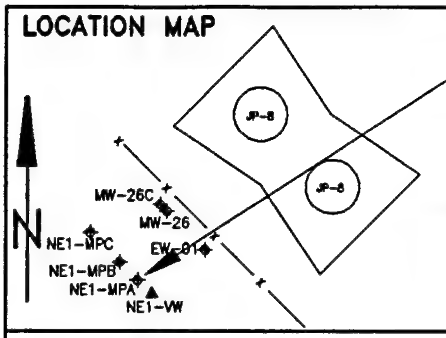
CASING ▶ TYPE 0.25" ID PVC — DIAMETER 0.5" — LENGTH 55', 65' & 70' — HOLE DIA. 8"

SCREEN ▶ TYPE Sch 40 PVC — SLOT 0.040" — DIAMETER 1" — LENGTH 6" — TOTAL DEPTH 70'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	WELL COMPLETION
dry		hard	x hard			20	0.71		0.00'-0.71' CALICHE, white to buff, massive.	
dry		dense	hard			25			Cuttings - CLAY AND SILT, light brown, little caliche. (ML)	
dry		m dense	plas			30			0.00'-1.02' CLAY AND SILT, light brown, some caliche nodules. (ML)	
dry		v stiff	v plas			31	0.89		1.02'-1.50' CLAY, light yellowish brown, some silt, trace of very fine-grained sand. (CH)	
dry		v stiff	v plas			35			Cuttings - Same as above.	

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

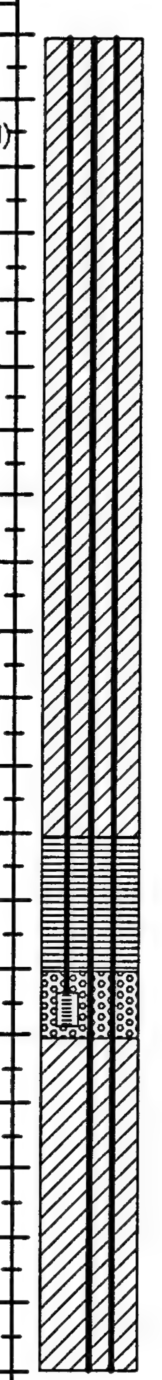
EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP	Nellis AFB - Bioventing Pilot Study			PAGE 3 OF 4
	WELL NUMBER ▶ NE1-MPA		LOCATION ▶ 35' SW of Tank Farm Fence	
	DATE ▶ 1-14-94		WEATHER ▶ Clear, Calm 40°F	
	LOGGED BY ▶ S. Pearson		DRILLED BY ▶ EnviroDrill	
	DRILLING METHOD ▶ 4-1/4" ID Hollow-stem Auger		SAMPLING METHOD ▶ 0' -65' 1.5" S/S 65'-75' 2.0" S/S	
	GRAVEL PACK ▶ Colorado Silica #6-9		SEAL ▶ Holeplug 1/4" Bentonite	

CASING ▶ TYPE 0.25" ID PVC	DIAMETER 0.5"	LENGTH 55', 65' & 70'	HOLE DIA. 8"
SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 70'

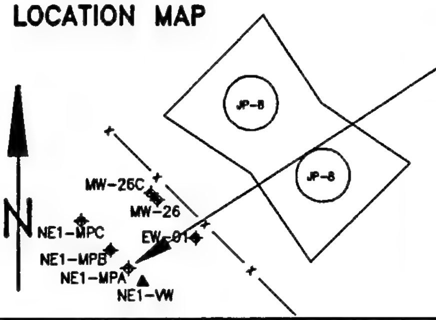
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	
dry		hard	x hard			40		31	0.00'-0.36'	CALICHE, white, massive.
damp		v stiff	v plas		36		1.53	39	0.36'-1.37'	CLAY, light yellowish brown, trace of silt and very fine-grained sand. (CH)
dry		v stiff	v plas			41		49	1.37'-1.53'	MARL, light yellowish brown and white. (CH)
						42				
						43				
						44				
damp	poor	m dense	non		22	45	1.08	18, 28, 37	0.00'-1.08'	SAND, light yellowish brown, fine-grained, and very fine-grained, subangular, little clay and silt. (ML)
						46				
						47				
						48				
						49				
						50		28	0.00'-0.25'	CAVINGS, sand as above.
dry		hard	x hard		36		1.24	12	0.25'-0.68'	CLAY, light brown, little silt, partial calcium carbonate cementation. (CH)
damp-moist		soft	sl plas			51		18	0.68'-1.24'	CLAY, light yellowish brown, little silt, trace of clay. (CL)
						52				
						53			Note:	Clays appear to be wetter than in NE1-VW. Possibly water used to hydrate the holeplug in NE1-VW has saturated the nearby clays.
						54				
damp-moist		soft	sl plas			55		7	0.00'-1.22'	CLAY, same as above.
damp		v stiff	v plas		63	56	1.51	14, 27	1.22'-1.51'	CLAY, light brown, some silt, partial calcium carbonate cementation, little amount of caliche nodules. (CH)
						57				
						58				
						59				
						60				

WELL COMPLETION



EXPLANATION: GROUT, BENTONITE, SAND, CASING, SCREEN, WATER LEVEL, HOLEPLUG

LOCATION MAP	Nellis AFB - Bioventing Pilot Study	PAGE 4 OF 4

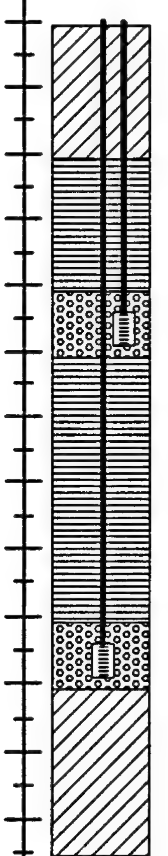


WELL NUMBER	NE1-MPA	LOCATION	35' SW of Tank Farm Fence
DATE	1-14-94	WEATHER	Clear, Calm 40°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -65' 1.5" S/S 65'-75' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING	TYPE 0.25" ID PVC		DIAMETER 0.5"		LENGTH 55', 65' & 70'		HOLE DIA. 8"			
SCREEN	TYPE Sch 40 PVC	SLOT 0.040"	DIAMETER 1"		LENGTH 6"		TOTAL DEPTH 70'			

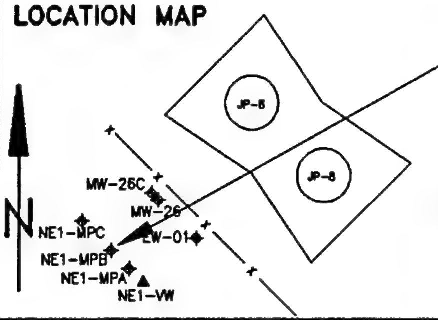
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
moist		soft	sl plas		200	60	1.51	9 15 50=2"	0.00'-1.55' CLAY, light yellowish brown, trace of silt. (CL)
						61			
						62			
						63			Driller reports caliche. Hard Drilling.
						64			
moist		soft	sl plas	NE1-MPA-65	220	65	1.50	32 20 25	0.00'-1.50' CLAY, same as above.
						66			
						67			
						68			
						69			
damp		stiff	plas	NE1-MPA-70	540	70	1.50	19 25 43	0.00'-1.50' CLAY, light yellowish brown, little silt and small caliche pebbles. (CL)
						71			
						72			
						73			
						74			
						75			
						76			
						77			
						78			
						79			
						80			

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



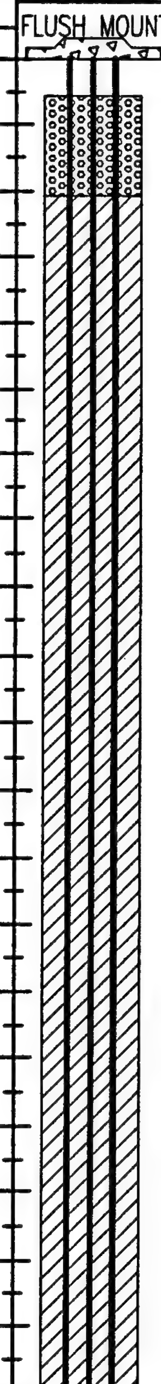
Nellis AFB - Bioventing Pilot Study

WELL NUMBER	NE1-MPB	LOCATION	35' SW of Tank Farm Fence
DATE	1-14-94	WEATHER	Clear, Calm 65°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -65' 1.5" S/S 65'-75' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING	TYPE 0.25" ID PVC		DIAMETER 0.5"	LENGTH 55', 65' & 70'	HOLE DIA. 8"
SCREEN	TYPE Sch 40 PVC	SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 70'

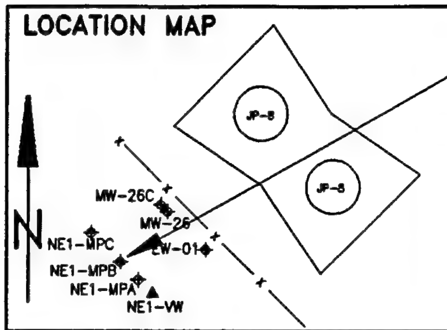
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
						0			
						1			
						2			
						3			
						4			
						5			
						6			
						7			
						8			
						9			
dry	poor	dense	non			10		6	0.00'-1.05' CLAY, SILT AND SAND, light brown, some caliche gravel. (SC)
							1.05	17	
						11		50=2.5"	
						12			
						13			
						14			
						15			Cuttings - SILT AND CLAY, light brown.
						16			
						17			
						18			
						19			
						20			

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

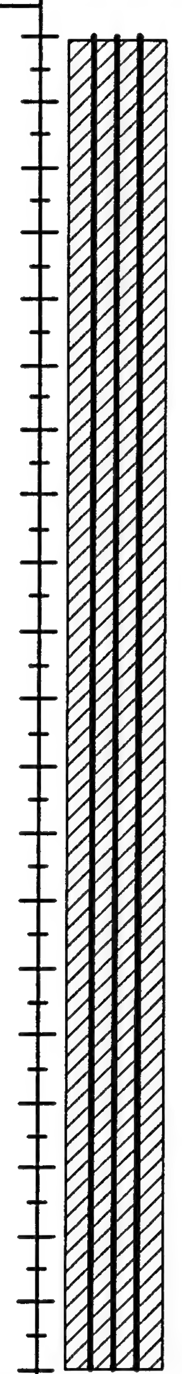
WELL NUMBER	NE1-MPB	LOCATION	35' SW of Tank Farm Fence
DATE	1-14-94	WEATHER	Clear, Calm 65°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -65' 1.5" S/S 65'-75' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING ▶ TYPE 0.25" ID PVC DIAMETER 0.5" LENGTH 55', 65' & 70' HOLE DIA. 8"

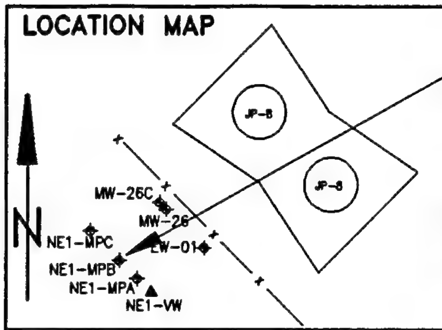
SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040" DIAMETER 1" LENGTH 6" TOTAL DEPTH 70'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	
						20		50=3"	0.00'-0.33'	Cavings.
dry		hard	x hard				1.06	–	0.33'-1.06'	CALICHE, white to light brown, massive.
						21		–		
						22				
						23				
						24				
						25			Cuttings –	CLAY AND SILT, light brown, little caliche gravel.
						26				
						27				
						28				
						29				
dry		m stiff	non			30		4	0.00'-0.80'	CLAY AND SILT, light yellowish brown, some very fine-grained sand. (SC)
							0.80	7		
						31		8		
						32				
						33				
						34				
dry		m stiff	plas			35			Cuttings –	CLAY, light yellowish brown, trace of caliche pebbles and very fine-grained sand.
						36				
						37				
						38				
						39				
						40				

WELL COMPLETION



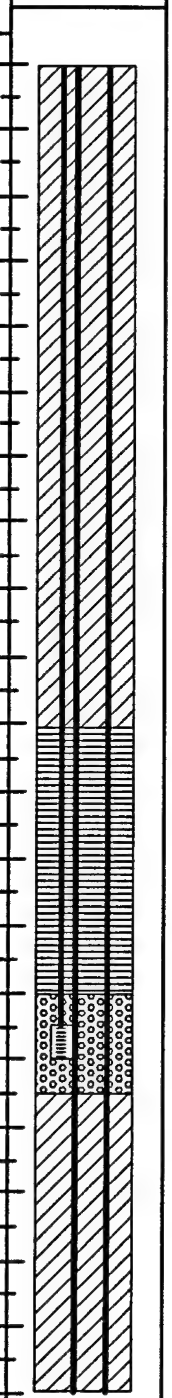
EXPLANATION GROUT SAND SCREEN HOLEPLUG BENTONITE CASING WATER LEVEL

LOCATION MAP	Nellis AFB - Bioventing Pilot Study			PAGE 3 OF 4
	WELL NUMBER ▶ NE1-MPB		LOCATION ▶ 35' SW of Tank Farm Fence	
	DATE ▶ 1-14-94		WEATHER ▶ Clear, Calm 65°F	
	LOGGED BY ▶ S. Pearson		DRILLED BY ▶ EnviroDrill	
	DRILLING METHOD ▶ 4-1/4" ID Hollow-stem Auger		SAMPLING METHOD ▶ 0' -65' 1.5" S/S 65'-75' 2.0" S/S	
	GRAVEL PACK ▶ Colorado Silica #6-9		SEAL ▶ Holeplug 1/4" Bentonite	

CASING ▶ TYPE 0.25" ID PVC	DIAMETER 0.5"	LENGTH 55', 65' & 70'	HOLE DIA. 8"
SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 70'

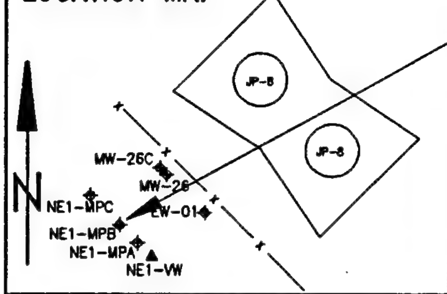
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	
dry		m stiff	plas		82	40	0.76	11 / 17 / 10	0.00'-0.76'	CLAY, light yellowish brown, trace of silt and very fine-grained sand. (CL)
						41–44				
dry		m stiff	sl plas		100	45	1.55	10 / 35 / 35	0.00'-0.65'	CLAY AND SILT, light yellowish brown, somve very fine-grained sand. (ML)
dry	poor	dense	non			46			0.65'-1.55'	SAND, light yellowish brown, very fine- and fine-grained sand, little clay and silt, appearent hydrocarbon staining. (SC)
						47–49				
damp	poor	m dense	sl plas		460	50	1.52	10 / 26 / 21	0.00'-0.53'	SAND, same as above.
damp		stiff	plas						0.53'-0.91'	CLAY, light yellowish brown, some silt and very fine-grained sand. (CL)
moist		soft	sl plas			51			0.91'-1.16'	CLAY, light yellowish brown, trace of silt and very fine-grained sand. (CL)
dry		m stiff	plas			52			1.16'-1.52'	CLAY, light yellowish brown, some silt and very fine-grained sand, little amount of caliche pebbles. (CL)
						53–54				
damp		m stiff	plas		115	55	1.42	9 / 9 / 10	0.00'-0.87'	CLAY, light yellowish brown, some silt, little amount of caliche pebbles. (CL)
damp		m stiff	plas			56			0.87'-1.42'	CLAY, light yellowish brown, little silt and no caliche. (CL)
						57–60				

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

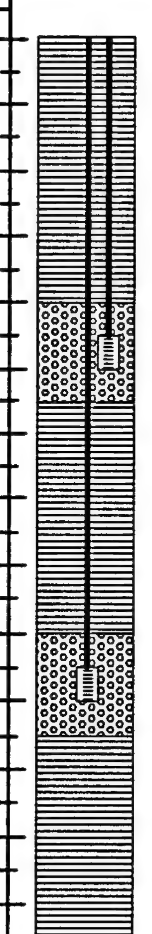
WELL NUMBER	NE1-MPB	LOCATION	35' SW of Tank Farm Fence
DATE	1-14-94	WEATHER	Clear, Calm 65°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -65' 1.5" S/S 65'-75' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING ▶ TYPE 0.25" ID PVC — DIAMETER 0.5" — LENGTH 55', 65' & 70' — HOLE DIA. 8"

SCREEN ▶ TYPE Sch 40 PVC — SLOT 0.040" — DIAMETER 1" — LENGTH 6" — TOTAL DEPTH 70'

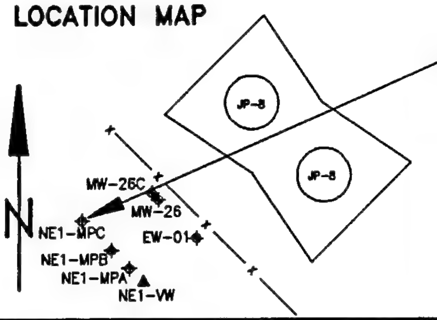
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	
damp		v stiff	v plas			60		6	0.00'-1.05'	CLAY, as above. Caliche zones at 0.1' and 0.5' (CH)
damp		v stiff	v plas		28	61	1.53	28 50=3"	1.05'-1.53'	CLAY, light yellowish brown, some silt and very fine-grained sand, little amount of caliche pebbles. (CH)
						62				
						63				
						64				
						65		50=3"	0.00'-1.00'	Cavings.
damp	poor	dense	non	NE1-MPB-65	2600	66	1.50	- -	1.00'-1.50'	CLAY, SILT AND SAND, pale brown to light yellowish brown, very fine-grained, hydrocarbon odor. (ML)
						67				
						68				
dry	poor	dense	non			69		17	0.00'-1.00'	Cavings.
				NA		70	1.00	50=5" -		
dry		hard	x hard	NE1-MPB-71	6600	71	1.50	117 125 112	0.00'-1.50'	CLAY, light yellowish brown, little silt and very fine-grained sand, very hard, large caliche cobbles are present. (CH)
						72				
						73				
						74				
						75				
						76				
						77				
						78				
						79				
						80				

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

WELL NUMBER	NE1-MPC	LOCATION	20' NW ofNE1-MPB
DATE	1-15-94	WEATHER	Clear, Calm 65°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -65' 1.5" S/S 65' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

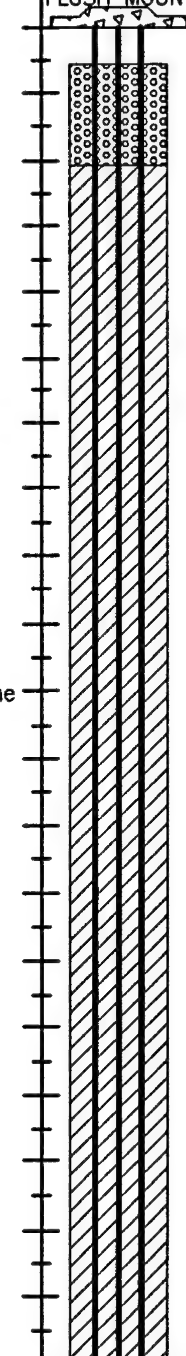
CASING ▶ TYPE 0.25" ID PVC DIAMETER 0.5" LENGTH 55', 65' & 70' HOLE DIA. 8"

SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040" DIAMETER 1" LENGTH 6" TOTAL DEPTH 70'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
						0			
						1			
						2			
						3			
						4			
						5			
						6			
						7			
						8			
						9			
dry	poor	dnese	non			10	0.64	50=3.5"	0.00'-0.64' CLAY, SILT AND SAND, pale brown, some caliche gravel. (ML)
						11			
						12			
						13			
						14			
						15			
						16			
						17			
						18			
						19			
						20			

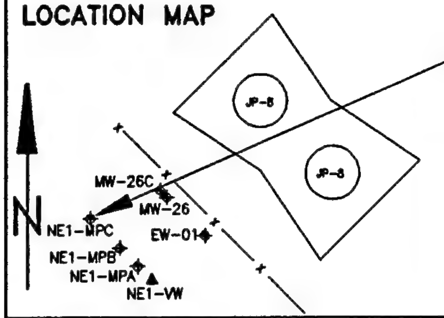
WELL COMPLETION

FLUSH MOUNT



EXPLANATION GROUT SAND SCREEN HOLEPLUG BENTONITE CASING WATER LEVEL

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

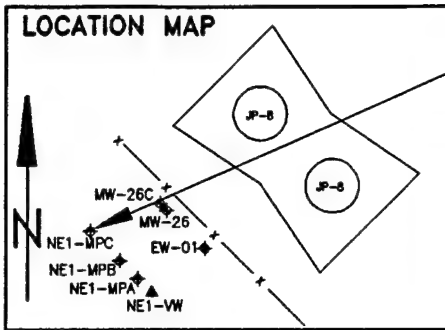
WELL NUMBER	NE1-MPC	LOCATION	20' NW of NE1-MPB
DATE	1-15-94	WEATHER	Clear, Calm 65°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -65' 1.5" S/S 65' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING ▶ TYPE 0.25" ID PVC — DIAMETER 0.5" — LENGTH 55', 65' & 70' — HOLE DIA. 8"

SCREEN ▶ TYPE Sch 40 PVC — SLOT 0.040" — DIAMETER 1" — LENGTH 6" — TOTAL DEPTH 70'

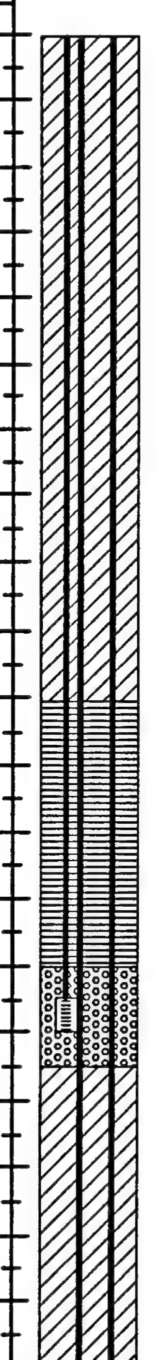
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	WELL COMPLETION
dry		hard	x hard			20	NR	50=1.5"	No Recovery— CALICHE, white to pale brown, massive.	
						21				
						22				
						23				
						24				
dry		stiff	v plas			25			Cuttings — CLAY, pale brown, some silt and very fine-grained sand.	
						26				
						27				
						28				
						29				
dry		m stiff	plas			30		12	0.00'–0.40' CLAY, SILT AND CALICHE, pale brown.	
dry		m stiff	sl plas				1.50	18	0.40'–1.50' CLAY, light yellowish brown, some silt, trace of very fine-grained sand, some caliche pebbles.	
						31		24		
						32				
						33				
						34				
						35				
						36				
						37				
						38				
						39				
						40				

EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP	Nellis AFB - Bioventing Pilot Study			PAGE 3 OF 4
	WELL NUMBER ▶ NE1-MPC		LOCATION ▶ 20' NW ofNE1-MPB	
	DATE ▶ 1-15-94		WEATHER ▶ Clear, Calm 65°F	
	LOGGED BY ▶ S. Pearson		DRILLED BY ▶ EnviroDrill	
	DRILLING METHOD ▶ 4-1/4" ID Hollow-stem Auger		SAMPLING METHOD ▶ 0' -65' 1.5" S/S 65' 2.0" S/S	
	GRAVEL PACK ▶ Colorado Silica #6-9		SEAL ▶ Holeplug 1/4" Bentonite	

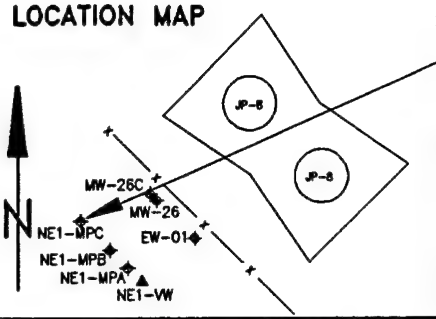
CASING ▶ TYPE 0.25" ID PVC	DIAMETER 0.5"	LENGTH 55', 65' & 70'	HOLE DIA. 8"
SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 70'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS		WELL COMPLETION
dry		hard	x hard		140	40	0.88	41 50=3" –	0.00'–0.88'	CALICHE, CLAY AND SILT, pale brown to white, caliche is pebble to cobble-sized.	
						41					
						42					
						43					
						44					
damp		m stiff	plas		290	45	1.48	8 16 25	0.00'–1.13'	CLAY AND SAND, light yellowish brown, very fine-grained, some silt.	
damp	poor	m dens	sl plas			46			1.13'–1.48'	SAND, light yellowish brown, fine- and very fine-grained, subrounded, some clay and silt.	
						47					
						48					
						49					
damp	poor	m dens	sl plas		>10,000	50	1.53	8 30 16	0.00'–0.86'	SAND, as above.	
damp-moist		m stiff	sl plas			51			0.86'–1.53'	CLAY, light yellowish brown, trace of silt and very fien-grained sand.	
						52					
						53					
						54					
damp		v stiff	plas		7800	55	1.51	50 50=3"	0.00'–0.39'	CLAY, as above, hydrocarbon odor.	
dry		v stiff	sl plas -non			56			0.39'–1.51'	CLAY, SILT AND SAND, pale brown, fine-grained.	
						57					
						58					
						59					
						60					



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

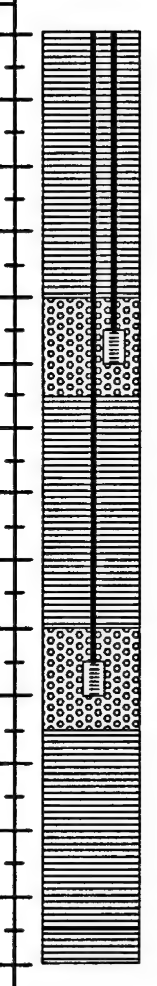
WELL NUMBER	NE1-MPC	LOCATION	20' NW ofNE1-MPB
DATE	1-15-94	WEATHER	Clear, Calm 65°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -65' 1.5" S/S 65' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING	TYPE 0.25" ID PVC	DIAMETER 0.5"	LENGTH 55', 65' & 70'	HOLE DIA. 8"
SCREEN	TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 70'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
damp		v stiff	plas		5500	60	1.51	14 / 50=5" / –	0.00'–0.53' Cavings. 0.53'–1.51' CLAY, light yellowish brown, trace of silt and very fine-grained sand, little amount of caliche pebbles.
dry		hard	x hard	NE1-MPC-65	760	65	1.50	110 / 35 / –	0.00'–1.50' CLAY AND CALICHE, light yellowish brown, trace of silt.
dry		hard	x hard		740	70	0.69	100=2" / – / –	0.00'–0.69' CLAY, pale brown, some silt and fine-grained sand.
						74			Overdrill to 74'. Encounter groundwater at 74'.

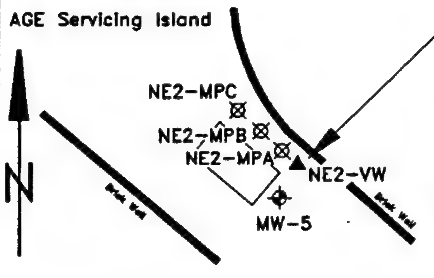
DEPTH scale: 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP	Nellis AFB – Bioventing Pilot Study	PAGE 1 OF 3

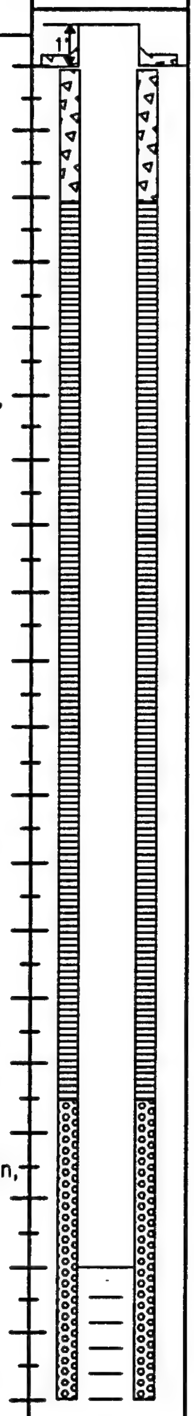


WELL NUMBER	NE2-VW	LOCATION	5' SW of Brick Wall
DATE	1-16/17-94	WEATHER	Clear, Calm 60°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	6-5/8" ID Hollow-stem Auger	SAMPLING METHOD	0' -15' 1.5" S/S; 15'-45' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9 43-15.5'	SEAL	1/4" Bentonite 15.5'-2'

CASING	TYPE Schedule 40 PVC		DIAMETER	4"	LENGTH	18'	HOLE DIA.	11"
SCREEN	TYPE Sch 40 PVC	SLOT 0.040"	DIAMETER	4"	LENGTH	25'	TOTAL DEPTH	43'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
damp	poor	loose	non			5	1.47	6	0.00'–0.54' SILT AND SAND, pale brown, fine-grained, little clay. (ML)
damp	poor	m stiff	sl plas			6		5, 6	0.54'–1.47' CLAY AND SILT, pale brown, little fine-grained sand. (CL)
damp		v stiff	plas			10	1.45	34	0.00'–0.95' CLAY AND SILT, as above.
dry		hard	x hard			11		50=5", –	0.95'–1.45' CALICHE, white to pale brown, massive.
damp		stiff	plas		310	15	0.93	20	0.00'–0.64' CLAY, light yellowish brown, some silt and caliche nodules, hydrocarbon-filled fractures. (CL)
damp		stiff	plas			16		50=1", –	0.64'–0.93 Clay, black-gray, stained with hydrocarbon, some silt and caliche nodules. (CL) Massive caliche in sampler shoe.

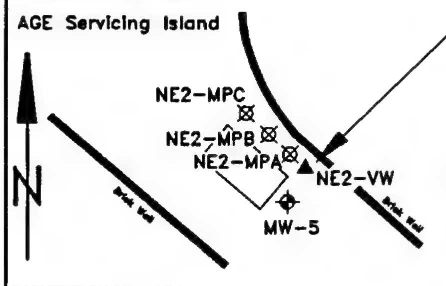
WELL COMPLETION



EXPLANATION: GROUT, BENTONITE, SAND, CASING, SCREEN, WATER LEVEL, HOLEPLUG

LOCATION MAP

AGE Servicing Island



Nellis AFB – Bioventing Pilot Study

WELL NUMBER	NE2-VW	LOCATION	5' SW of Brick Wall
DATE	1-16/17-94	WEATHER	Clear, Calm 60°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	6-5/8" ID Hollow-stem Auger	SAMPLING METHOD	0' -15' 1.5" S/S 15'-45' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9 43-15.5'	SEAL	1/4" Bentonite 15.5'-2'

CASING	TYPE Schedule 40 PVC		DIAMETER 4"	LENGTH 18'	HOLE DIA. 11"
SCREEN	TYPE Sch 40 PVC	SLOT 0.040"	DIAMETER 4"	LENGTH 25'	TOTAL DEPTH 43'

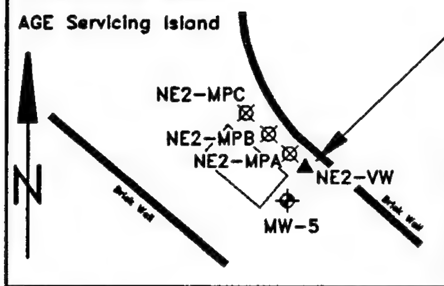
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	
dry		hard	x hard	NE2-VW-20	35	20	1.50	40, 50=4", –	0.00'-1.50'	CLAY AND CALICHE, light yellowish brown, some silt, hard drilling. (CH)
dry				NA	600	25		50=2", –, –	No Recovery–	Hard Drilling. Collected headspace sample from cuttings.
damp -dry		v stiff	v plas	NE2-VW-30	1200	30	1.50	28, 29, 50=5"	0.00'-1.50'	CLAY, pale brown, little silt and very fine-grained sand, trace of caliche. (CH)
						33			33'-35'	Hard Drilling.
dry		v stiff	v plas	NE2-VW-35		35		26, 50=5.5, –	0.00'-1.50'	CLAY, pale brown, some silt, trace of very fine-grained sand, moist zone at 1'. (CH)
						40			40'	Center plug is covered with hydrocarbon-stained soil.

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

WELL COMPLETION

EXPLANATION: GROUT, BENTONITE, SAND, CASING, SCREEN, WATER LEVEL, HOLEPLUG

LOCATION MAP	Nellis AFB – Bioventing Pilot Study	PAGE 3 OF 3

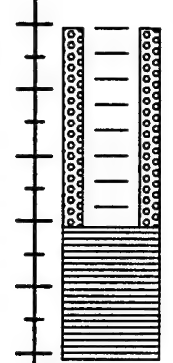


WELL NUMBER	NE2-VW	LOCATION	5' SW of Brick Wall
DATE	1-16/17-94	WEATHER	Clear, Calm 60°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	6-5/8" ID Hollow-stem Auger	SAMPLING METHOD	0' -15' 1.5" S/S 15'-45' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9 43-15.5'	SEAL	1/4" Bentonite 15.5'-2'

CASING	TYPE Schedule 40 PVC		DIAMETER 4"	LENGTH 18'	HOLE DIA. 11"
SCREEN	TYPE Sch 40 PVC	SLOT 0.040"	DIAMETER 4"	LENGTH 25'	TOTAL DEPTH 43'

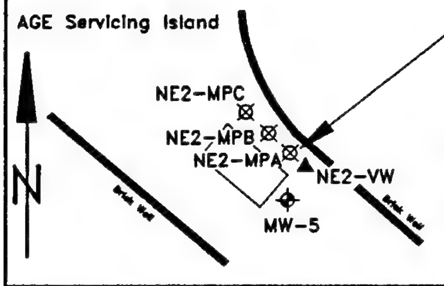
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
damp-moist		m stiff	sl plas	NE2-VW-40	1000	40	1.50	7	0.00'-1.30' CLAY, dark gray, trace of silt and very fine-grained sand, hydrocarbon staining. (CL)
						41		7	
dry		hard	x hard					28	1.30'-1.50' CALICHE, dark gray, massive, hydrocarbon stained.
						42			
						43			
						44			
						45			Drill to 45'. Encounter groundwater at 44' below grade. Plug boring with 1/4" bentonite pellets to 43'.
						46			
						47			
						48			
						49			
						50			
						51			
						52			
						53			
						54			
						55			
						56			
						57			
						58			
						59			
						60			

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB – Bioventing Pilot Study

WELL NUMBER	NE2-MPA	LOCATION	10' NW of NE2-VW
DATE	1-17-94	WEATHER	Clear, Calm 70°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -40' 1.5" S/S 24',32' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	1/4" Bentonite

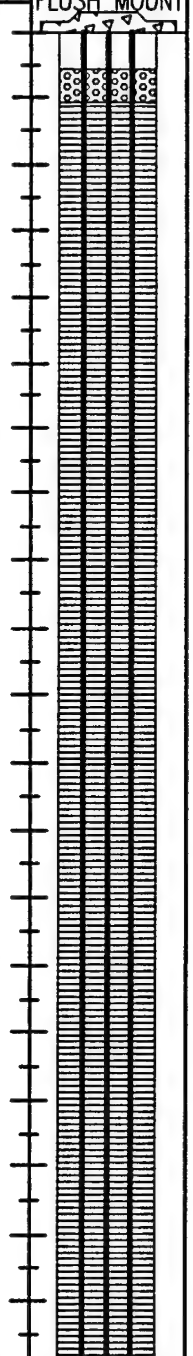
CASING ▶ TYPE 0.25" ID PVC DIAMETER 0.5" LENGTH 24', 32' & 39' HOLE DIA. 8"

SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040" DIAMETER 1" LENGTH 6" TOTAL DEPTH 40'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
damp		m stiff	plas			5			Cuttings – CLAY, pale brown, some silt. (CL)
damp		soft	sl plas		780	15–16	1.01	3 4 5/	0.00'–1.01' CLAY, light yellowish brown, some silt and fine-grained sand, slight hydrocarbon odor. (CL)

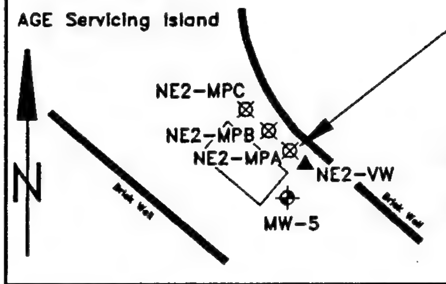
WELL COMPLETION

FLUSH MOUNT



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

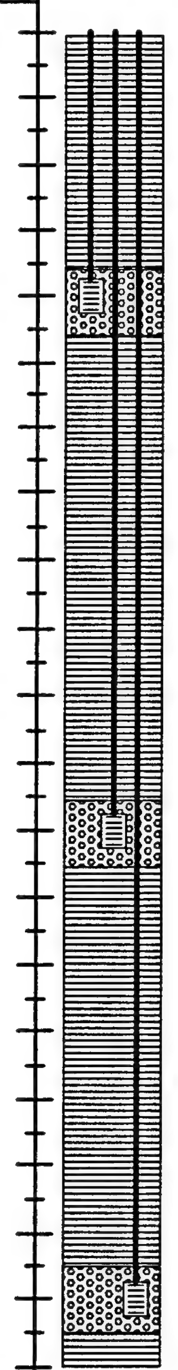
LOCATION MAP	Nellis AFB – Bioventing Pilot Study			PAGE 2 OF 2
	WELL NUMBER ▶ NE2–MPA		LOCATION ▶ 10' NW of NE2–VW	
	DATE ▶ 1–17–94		WEATHER ▶ Clear, Calm 70°F	
	LOGGED BY ▶ S. Pearson		DRILLED BY ▶ EnviroDrill	
	DRILLING METHOD ▶ 4–1/4" ID Hollow–stem Auger		SAMPLING METHOD ▶ 0' –40' 1.5" S/S 24',32' 2.0" S/S	
	GRAVEL PACK ▶ Colorado Silica #6–9		SEAL ▶ 1/4" Bentonite	



CASING ▶ TYPE 0.25" ID PVC	DIAMETER 0.5"	LENGTH	HOLE DIA. 8"
SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 40'

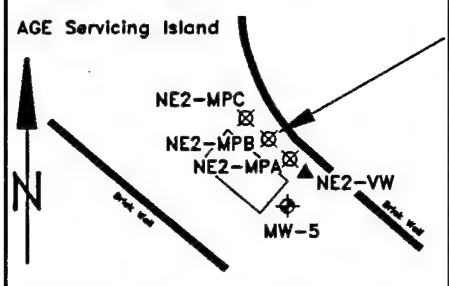
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
dry	poor	dense	non		880	20	0.78	50=4" / – / –	0.00'–0.78' CLAY, SILT AND SAND, pale brown, very fine-grained, extremely dry and brittle, probably hit caliche at 20.5', clay is preferentially cemented. (ML)
dry		stif	x hard	NE2–MPA–24	1600	25	1.50	11 / 50=5.5" / –	0.00'–1.50' CLAY, light yellowish brown, some silt, partially cemented with $CaCO_3$, brittle, (CH)
dry	poor	v stiff	non		2700	30	1.11	36 / 50=4" / –	0.00'–0.45' Cavings. 0.45'–1.11' CLAY, SILT AND SAND, pale brown, partially cemented, brittle. (ML)
dry	poor	v stiff	non	NE2–MPA–32	2500	31–32	1.00	175 / 100=1" / –	0.00'–1.00' Same as above. Refusal at 32.5' – Caliche expected.
dry		v stiff	v plas		1200	35	1.50	24 / 50=6" / –	0.00'–0.13' Cavings. 0.13'–1.50' CLAY, pale brown, some silt. (CH)
moist		stiff	plas			38–40			0.00'–1.24' CLAY, light yellowish brown, little silt and very fine-grained sand, small caliche lenses at 0.46', stained gray with hydrocarbons, slight odor. (CL)

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB – Bioventing Pilot Study

WELL NUMBER	NE2-MPB	LOCATION	15' NW of NE2-MPA
DATE	1-17-94	WEATHER	Clear, Calm 70°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -40' 1.5" S/S 24',32' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	1/4" Bentonite

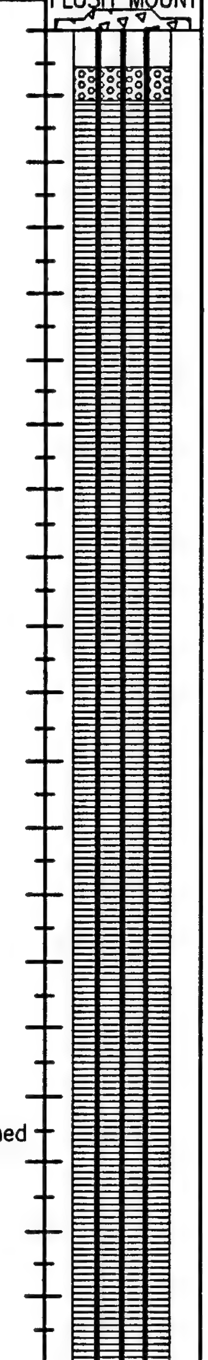
CASING ▶ TYPE 0.25" ID PVC DIAMETER 0.5" LENGTH 24', 32' & 39' HOLE DIA. 8"

SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040" DIAMETER 1" LENGTH 6" TOTAL DEPTH 40'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
						0			
						1			
						2			
						3			
						4			
damp		m stiff	plas			5			Cuttings – CLAY, pale brown, some silt. (CL)
						6			
						7			
						8			
						9			
						10			
						11			
						12			
						13			
						14			
dry		stiff	plas			15		4	0.00'–0.61' CLAY, light yellowish brown, some silt and very fine-grained sand. (CL)
damp		m stiff	plas		58	16	1.50	5 6	0.61'–1.50' CLAY AND SILT, dark gray, hydrocarbon staining and odor, some very fine-grained sand, some iron staining. (ML)
						17			
						18			
						19			Stained cuttings to 19'
						20			

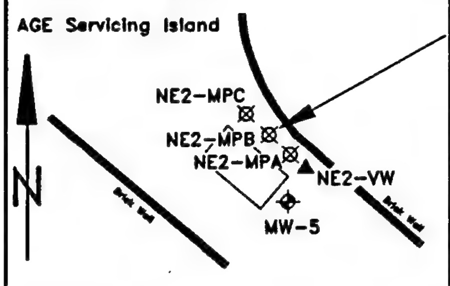
WELL COMPLETION

FLUSH MOUNT



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP	Nellis AFB – Bioventing Pilot Study	PAGE 2 OF 2

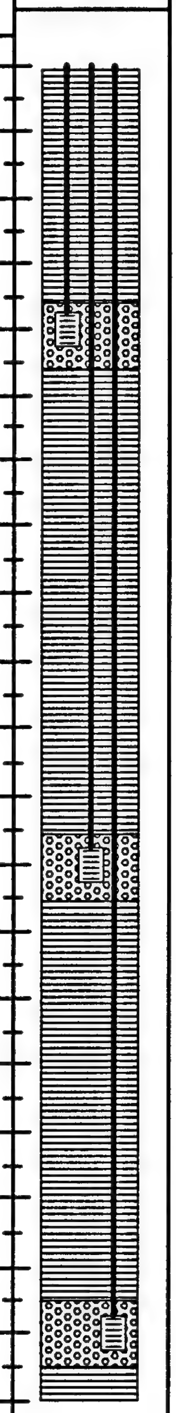


WELL NUMBER	NE2-MPB	LOCATION	15' NW of NE2-MPA
DATE	1-17-94	WEATHER	Clear, Calm 70°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -40' 1.5" S/S 24',32' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	1/4" Bentonite

CASING	TYPE 0.25" ID PVC		DIAMETER 0.5"	LENGTH		HOLE DIA.	8"
SCREEN	TYPE Sch 40 PVC	SLOT 0.040"	DIAMETER 1"	LENGTH	6"	TOTAL DEPTH	40'

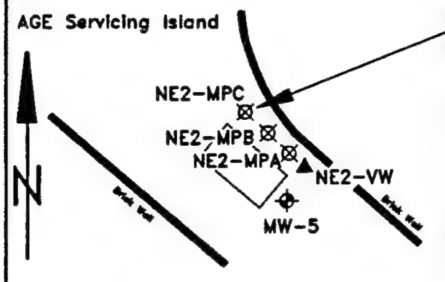
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
dry	poor	v stiff	non		510	20–21	0.87	50=5" – –	0.00'–0.33' Cavings. 0.33'–0.87' CLAY, SILT AND SAND, pale brown, very fine-grained, dry and brittle, caliche is expected below. (ML)
dry		stiff	plas	NE2-MPB-24	200	24–25	1.50	9 10 26	Hydrocarbon-stained cuttings at 24' 0.00'–1.50' CLAY, pale brown, some silt, partially cemented, hydrocarbon staining. (CL)
dry		hard	x hard	NE2-MPB-32	240	30.5–32	1.50	300 200 –	0.00'–0.50' Cavings. 0.50'–1.50' CLAY, SILT AND SAND, pale brown, very fine-grained, well cemented. (ML)
damp		stiff	plas		1200	35–36.5	1.50	27 50=4.5" –	0.00'–1.50' CLAY, light yellowish brown, some silt, definite vertical fracturing with hydrocarbon staining (see photo). (CL)
moist		stiff	plas		4600	38.5–40	1.50	10 9 13	0.00'–0.88' CLAY, light yellowish brown, little silt and very fine-grained sand. (CL)
moist		stiff	plas						0.98'–1.50' CALICHE AND INTERBEDDED CLAY, caliche is white and clay is stained black. (CL)

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP	Nellis AFB – Bioventing Pilot Study			PAGE 1 OF 2
	WELL NUMBER ▶ NE2–MPC	LOCATION ▶ 15' NW of NE2–MPA		
	DATE ▶ 1–18–94	WEATHER ▶ Clear, Calm 70°F		
	LOGGED BY ▶ S. Pearson	DRILLED BY ▶ EnviroDrill		
	DRILLING METHOD ▶ 4–1/4" ID Hollow–stem Auger	SAMPLING METHOD ▶ 2' x 1.5" S/S		
	GRAVEL PACK ▶ Colorado Silica #6–9	SEAL ▶ 1/4" Bentonite		



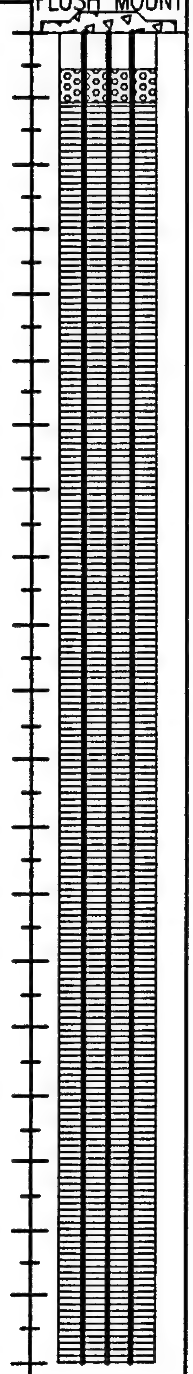
CASING ▶ TYPE 0.25" ID PVC — DIAMETER 0.5" — LENGTH 24', 32' & 39' — HOLE DIA. 8"

SCREEN ▶ TYPE Sch 40 PVC — SLOT 0.040" — DIAMETER 1" — LENGTH 6" — TOTAL DEPTH 40'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
damp		m stiff	plas			5			Cuttings – CLAY, pale brown, some silt.
damp		m stiff	plas		830	15	1.51	3, 5, 6	0.00'–1.51' CLAY AND SILT, black, hydrocarbon staining, little very fine-grained sand. (CL)
						19			Hydrocarbon staining to 19'

WELL COMPLETION

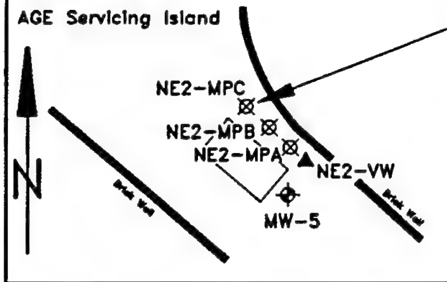
FLUSH MOUNT



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

Nellis AFB – Bioventing Pilot Study	**PAGE** 2 **OF** 2

LOCATION MAP

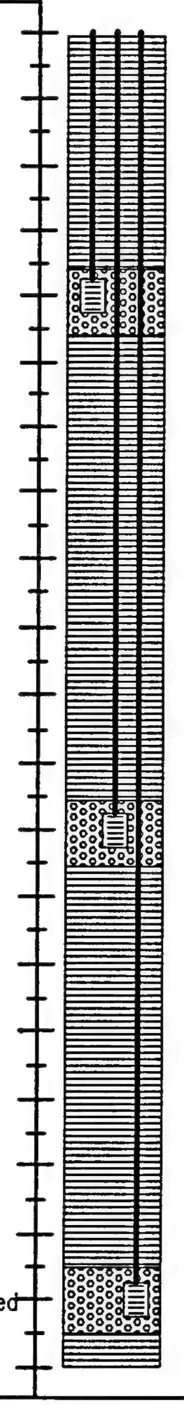


WELL NUMBER	NE2-MPC	**LOCATION**	15' NW of NE2-MPA
DATE	1-18-94	**WEATHER**	Clear, Calm 70°F
LOGGED BY	S. Pearson	**DRILLED BY**	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	**SAMPLING METHOD**	2' x 1.5" S/S
GRAVEL PACK	Colorado Silica #6-9	**SEAL**	1/4" Bentonite

CASING	**TYPE** 0.25" ID PVC	**DIAMETER** 0.5"	**LENGTH**	**HOLE DIA.** 8"
SCREEN	**TYPE** Sch 40 PVC **SLOT** 0.040"	**DIAMETER** 1"	**LENGTH** 6"	**TOTAL DEPTH** 40'

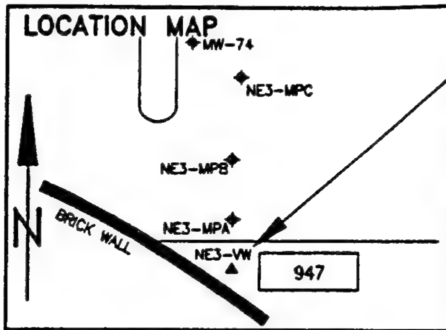
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
dry	poor	v dstif	non		1300	20–21	0.78	50=5" / – / –	0.00'–0.25' Cavings. 0.25'–0.78' CLAY, SILT AND SAND, pale brown, very fine-grained, dry and brittle. (ML)
damp		m stiff	sl plas		2700	25–26	1.52	4 / 4 / 6	0.00'–1.52' CLAY AND SILT, pale brown with gray hydrocarbon staining, some very fine-grained sand, caliche lense at 0.38'. (ML)
damp		m stiff	plas		4100	30–31	1.50	6 / 9 / 45	0.00'–1.16' CLAY AND SILT, pale brown, slight hydrocarbon staining, some very fine-grained sand and caliche pebbles. (CL)
dry		hard	v plas						1.16'–1.50' CLAY, as above, partially cemented, brittle and dry. (CH)
damp		v stiff -hard	v plas		80	35–36	1.50	8 / 18 / 39	0.00'–1.50' CLAY, light yellowish brown, some silt, trace of very fine-grained sand. (CH)
damp-moist		stiff	plas		360	38–39	1.52		0.00'–1.39' CLAY, light yellowish brown, little silt and very fine-grained sand, caliche gravel lense at 0.83', hydrocarbon-stained fractures and sand lenses. (CL)
damp		hard	x hard			40			1.39'–1.52' CALICHE, gray, hydrocarbon-stained.

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



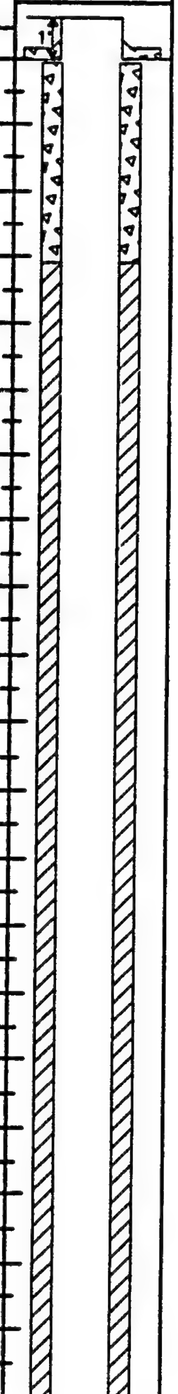
Nellis AFB - Bioventing Pilot Study		PAGE 1 OF 4	
WELL NUMBER	NE3-VW	LOCATION	15' NW of Building 947
DATE	1-19-94	WEATHER	Clear, Calm 60°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	6-5/8" ID Hollow-stem Auger	SAMPLING METHOD	0' -30' 1.5" S/S 30'-65' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9 65'-27'	SEAL	Holeplug 22'-3' 1/4" Bentonite 27'-22'

CASING	TYPE Schedule 40 PVC		DIAMETER 4"	LENGTH 30'	HOLE DIA. 11"
SCREEN	TYPE Sch 40 PVC	SLOT 0.040"	DIAMETER 4"	LENGTH 35'	TOTAL DEPTH 65'

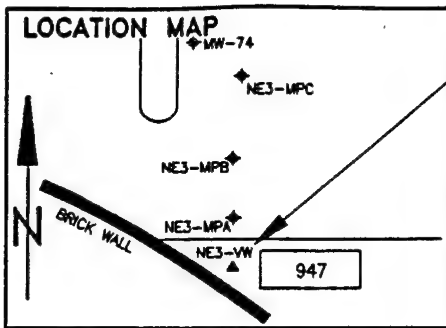
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
						0			Pilot hole with 4-1/4" ID HSA Overdrill with 6-5/8" ID HSA
dry	poor	m stiff	sl plas			5			Cuttings- CLAY, SILT AND SAND, light brown, very fine-grained sand. (SC)
damp		m stiff	sl plas		55	10–11	1.39	4 6 8	0.00'-0.27' Cavings. 0.27'-1.39' CLAY AND SAND, light yellowish brown, fine- and very fine-grained. (SC)

Depth scale: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

WELL COMPLETION



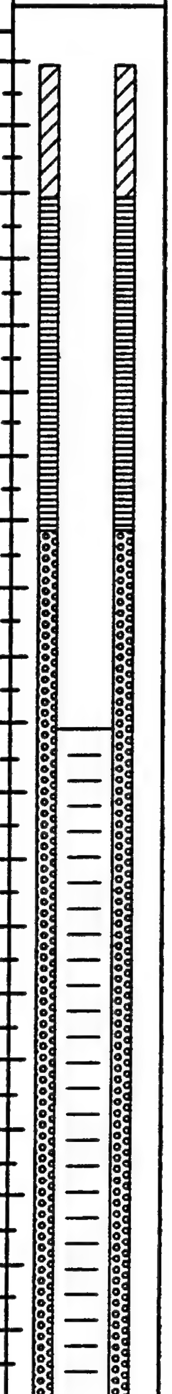
EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP	Nellis AFB – Bioventing Pilot Study			
	WELL NUMBER ▶ NE3–VW		LOCATION ▶ 15' NW of Building 947	
	DATE ▶ 1–19–94		WEATHER ▶ Clear, Calm 60°F	
	LOGGED BY ▶ S. Pearson		DRILLED BY ▶ EnviroDrill	
	DRILLING METHOD ▶ 6–5/8" ID Hollow–stem Auger		SAMPLING METHOD ▶ 0' –30' 1.5" S/S 30'–65' 2.0" S/S	
	GRAVEL PACK ▶ Colorado Silica #6–9 65'–27'		SEAL ▶ Holeplug 22'–3' 1/4" Bentonite 27'–22'	

CASING ▶ TYPE Schedule 40 PVC	DIAMETER 4"	LENGTH 30'	HOLE DIA. 11"
SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 4"	LENGTH 35'	TOTAL DEPTH 65'

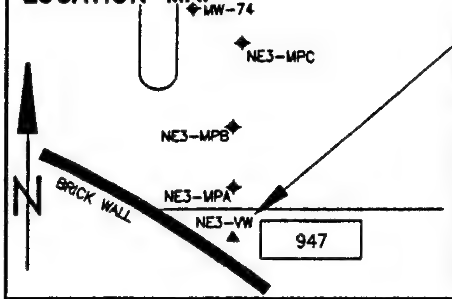
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	
damp		m stiff	sl plas		56	20	1.49	5	0.00'–0.33'	Cavings.
								9	0.33'–1.25'	Clay, light yellowish brown, some fine– and very fine–grained sand, little silt, mottled. (CL)
						21		10		
dry		m sitff	sl plas			22			1.25'–1.49'	CLAY AND SAND, light brown, fine–grained, some silt, (SC)
						23				
						24				
damp		soft	sl plas		56	25	0.80	6	0.00'–0.80'	CLAY, light yellowish brown, some fine–grained sand, little silt and very fine–grained sand, slight mottling. (CL)
						26		5		
								5		
						27				
						28				
						29				
damp		m stiff	sl plas	NE3–VW–30	58	30	1.50	17	0.00'–1.50'	CLAY, pale brown, little silt and very fine–grained sand, trace of caliche pebbles. (CL)
						31		7		
								7		
						32				
						33				
						34				
damp		m stiff	sl plas	NE3–VW–35	54	35	1.50	4	0.00'–1.30'	CLAY, as above.
dry		hard	x hard					13	1.30'–1.50'	CALICHE, white to light brown, hard and masssive.
						36		50=3.5"		
						37				
						38				
						39				
						40				

WELL COMPLETION



EXPLANATION ▨ GROUT ▨ SAND ▭ SCREEN ▨ HOLEPLUG ▤ BENTONITE ▭ CASING ▼ WATER LEVEL

LOCATION MAP



Nellis AFB – Bioventing Pilot Study		PAGE 3 OF 4

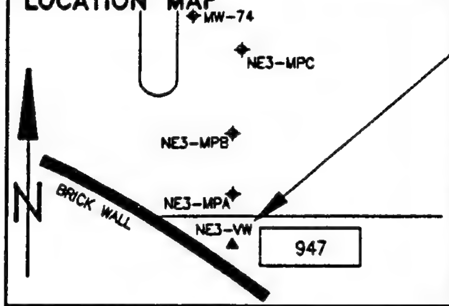
WELL NUMBER	NE3-VW	LOCATION	15' NW of Building 947
DATE	1-19-94	WEATHER	Clear, Calm 60°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	6-5/8" ID Hollow-stem Auger	SAMPLING METHOD	0' -30' 1.5" S/S 30'-65' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9 65'-27'	SEAL	Holeplug 22'-3' 1/4" Bentonite 27'-22'

CASING	TYPE Schedule 40 PVC	DIAMETER 4"	LENGTH 30'	HOLE DIA. 11"
SCREEN	TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 4"	LENGTH 35'	TOTAL DEPTH 65'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS		WELL COMPLETION
damp		stiff	plas	NE3-VW-40	92	40–41.5	1.30	20 19 18	0.00'–1.30'	CLAY, pale brown, some silt, fine- and very fine-grained sand, trace of caliche gravel. (CL)	
damp dry		v stiff hard	plas x hard	NE3-VW-45	57	45–46.5	1.20	19 32 30	0.00'–0.80' 0.80'–1.20'	CLAY, as above. CALICHE, light brown, massive.	
dry moist	 mod	hard m dense	v hard non	NE3-VW-50	7500	50–51.5	1.50	15 12 50	0.00'–0.40' 0.40'–1.50'	CALICHE, massive, pale brown. SAND, pale brown, fine- and very fine-grained, trace of silt, trace of hydrocarbon staining. (SM)	
damp-moist	poor	m stiff	plas	NE3-VW-55	1400	55–56.5	1.50	8 15 17	0.00'–1.50'	SAND AND CLAY, pale brown, fine- and very fine-grained sand, some silt, little hydrocarbon staining, little amount of caliche pebbles. (SC)	

EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB – Bioventing Pilot Study

WELL NUMBER	NE3-VW	LOCATION	15' NW of Building 947
DATE	1-19-94	WEATHER	Clear, Calm 60°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	6-5/8" ID Hollow-stem Auger	SAMPLING METHOD	0' -30' 1.5" S/S 30'-65' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9 65'-27'	SEAL	Holeplug 22'-3' 1/4" Bentonite 27'-22'

CASING ▶ TYPE Schedule 40 PVC DIAMETER 4" LENGTH 30' HOLE DIA. 11"

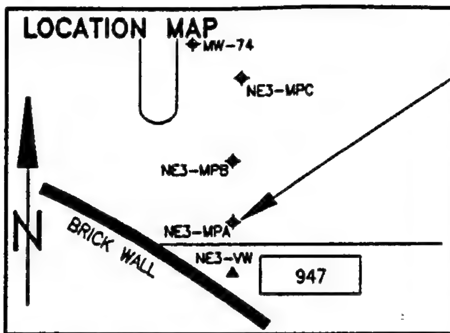
SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040" DIAMETER 4" LENGTH 35' TOTAL DEPTH 65'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
moist-wet		m stiff	plas	NE3-VW-60	750	60	1.50	10 14 15	0.00'-1.50' CLAY, pale brown, some silt and very fine-grained sand, little amount of caliche pebbles, hydrocarbon odor. (CL)
sat		hard	x hard	NE3-VW-65	>10,000	65	1.50	35 18 15	0.00'-1.00' CALICHE, light yellowish brown, gravelly, some clay and silt, saturated, strong hydrocarbon odor. (GC)
moist-wet		v stiff	v plas			66			1.00'-1.50' CLAY, light yellowish brown, some fine- and very fine-grained sand, some silt. (CH)

Depth scale: 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80

WELL COMPLETION

EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL



Nellis AFB - Bioventing Pilot Study

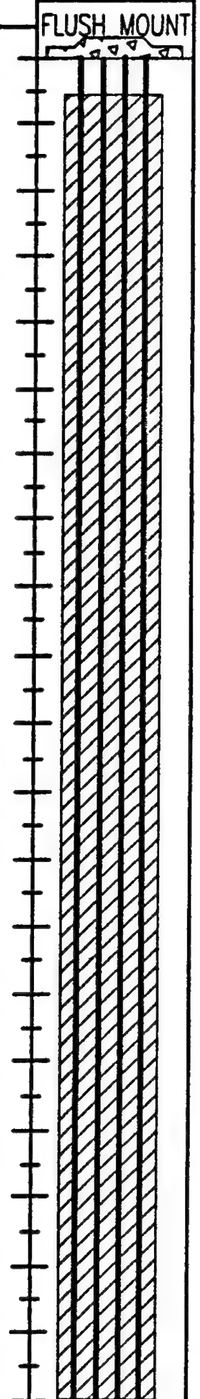
WELL NUMBER	NE3-MPA	LOCATION	15' N of NE3-VW
DATE	1-20-94	WEATHER	Clear, Calm - 35°F Midnight Drilling
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -60' 1.5" S/S 42' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING ▶ TYPE 0.25" ID PVC — DIAMETER 0.5" — LENGTH 30',40',50' & 60' — HOLE DIA. 8"

SCREEN ▶ TYPE Sch 40 PVC — SLOT 0.040" — DIAMETER 1" — LENGTH 6" — TOTAL DEPTH 60'

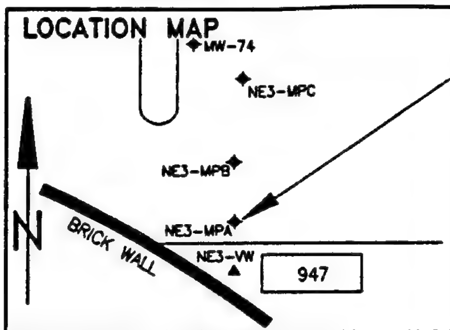
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
						0–9			
						10		3	0.00'-0.33' Cavings.
damp		soft	sl plas		320		1.13	3	0.33'-1.13' CLAY, pale brown, some silt and very fine-grained sand. (CL)
						11		4	
						12–20			

WELL COMPLETION: FLUSH MOUNT



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB – Bioventing Pilot Study

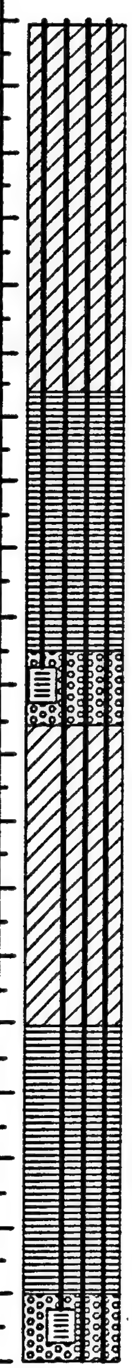
WELL NUMBER	NE3–MPA	LOCATION	15' N of NE3–VW
DATE	1–20–94	WEATHER	Clear, Calm – 35°F Midnight Drilling
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4–1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' –60' 1.5" S/S 42' 2.0" S/S
GRAVEL PACK	Colorado Silica #6–9	SEAL	Holeplug 1/4" Bentonite

CASING	TYPE 0.25" ID PVC	DIAMETER 0.5"	LENGTH 30',40',50' & 60'	HOLE DIA. 8"
SCREEN	TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 60'

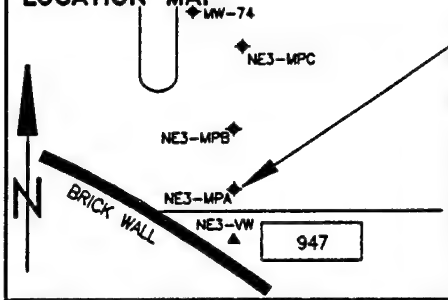
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
dry	poor	m dense	non		78	20–21	1.50	6 / 10 / 20	0.00'–1.50' SAND, pale brown, some silt and clay. (SM)
damp		m stiff	sl pas		94	25–26	1.51	2 / 4 / 5	0.00'–1.51' CLAY, light yellowish brown, some silt, fine and very fine-grained sand. (CL)
damp-moist		stiff	v plas		100	30–31	1.11	2 / 4 / 5	0.00'–0.50' Cavings. 0.50'–1.11' CLAY, pale brown, little silt and very fine-grained sand. (CH)
damp		stiff	v plas-x hard		120	35–36	1.41	6 / 32 / 42	0.00'–0.31' Cavings 0.31'–1.41' CLAY AND CALICHE, pale brown, some silt and very fine-grained sand, partially and preferentially cemented, caliche is interbedded. (CH)

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

WELL COMPLETION



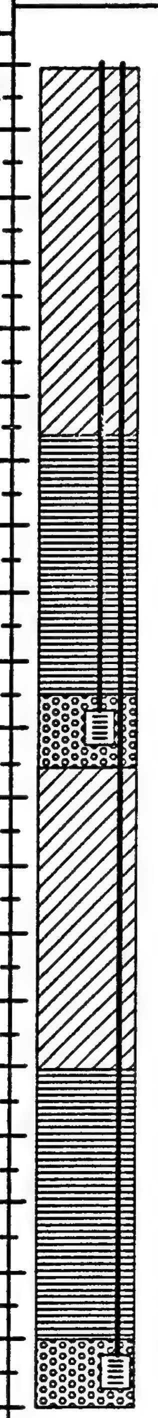
EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP	Nellis AFB – Bioventing Pilot Study			PAGE 3 OF 4
	WELL NUMBER ▶ NE3–MPA		LOCATION ▶ 15' N of NE3–VW	
	DATE ▶ 1–20–94		WEATHER ▶ Clear, Calm – 35°F Midnight Drilling	
	LOGGED BY ▶ S. Pearson		DRILLED BY ▶ EnviroDrill	
	DRILLING METHOD ▶ 4–1/4" ID Hollow–stem Auger		SAMPLING METHOD ▶ 0' –60' 1.5" S/S 42' 2.0" S/S	
	GRAVEL PACK ▶ Colorado Silica #6–9		SEAL ▶ Holeplug 1/4" Bentonite	

CASING ▶ TYPE 0.25" ID PVC	DIAMETER 0.5"	LENGTH 30',40',50' & 60'	HOLE DIA. 8"
SCREEN ▶ TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 60'

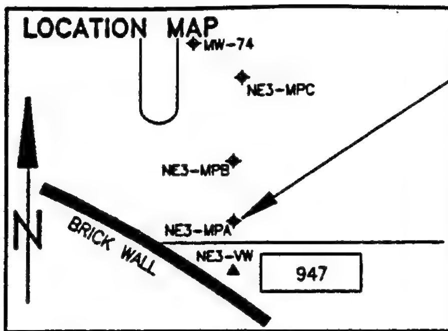
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
damp	mod	loose	non–sl plas		120	40–41.5	1.5	7, 7, 9	0.00'–1.50' SAND, light yellowish brown, fine and very fine–grained sand, little clay and silt. (SC)
damp		m stiff	plas	NE3–MPA–42	150	42–43.5	1.50	4, 5, 7	0.00'–1.50' CLAY, light yellowish brown, little silt and very fine–grained sand. (CL)
moist		m stiff	sl plas		250	45–46.5	1.50	5, 3, 7	0.00'–1.50' CLAY, light yellowish brown, little silt, trace of very fine–grained sand. (CL)
damp –wet	poor	m stiff	sl plas		7200	50–51.5	0.97	10, 12, 14	0.00'–0.97' CLAY, SILT AND SAND, light yellowish brown, fine– and very fine–grained sand, hydrocarbon odor. (SC)
damp		m stiff	plas		2000	55–56.5	0.87	5, 10, 6	0.00'–0.87' CLAY, light yellowish brown, little silt, little caliche pebbles, trace of very fine–grained sand. (CL)

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



WELL NUMBER	NE3-MPA	LOCATION	15' N of NE3-VW
DATE	1-20-94	WEATHER	Clear, Calm – 35°F Midnight Drilling
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0' -60' 1.5" S/S 42' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING ▶ TYPE 0.25" ID PVC | DIAMETER 0.5" | LENGTH 30',40',50' & 60' | HOLE DIA. 8"

SCREEN ▶ TYPE Sch 40 PVC | SLOT 0.040" | DIAMETER 1" | LENGTH 6" | TOTAL DEPTH 60'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	WELL COMPLETION
damp		stiff	plas			60		7	0.00'–1.50' CLAY, light yellowish brown, some silt, little fine-grained sand. (CL)	
					1300		1.50	10		
						61		11		
						62				
						63				
						64				
						65				
						66				
						67				
						68				
						69				
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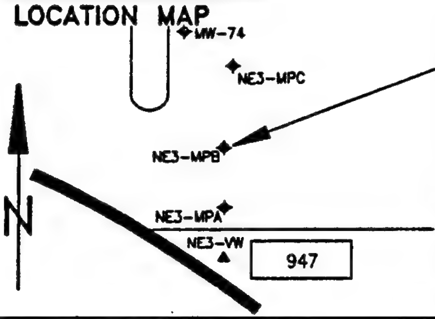
						79				
						80				

EXPLANATION: GROUT | SAND | SCREEN | HOLEPLUG | BENTONITE | CASING | WATER LEVEL

LOCATION MAP



Nellis AFB - Bioventing Pilot Study

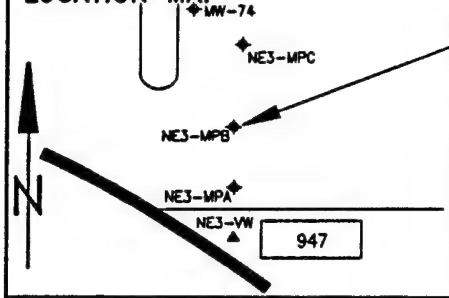
WELL NUMBER	NE3-MPB	LOCATION	15' N of NE3-MPA
DATE	1-19-94	WEATHER	Clear, Calm - 50°F Midnight Drilling
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0'-60' 1.5" S/S 30',40',50' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING	TYPE 0.25" ID PVC	DIAMETER 0.5"	LENGTH 30',40',50' & 60'	HOLE DIA. 8"
SCREEN	TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 60'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	WELL COMPLETION
										FLUSH MOUNT
damp		soft	sl plas -non		64	10-11.5	1.50	4 5 7	0.00'-1.50' CLAY AND SILT, light yellowish brown, little fine- and very fine-grained sand. (ML)	

EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP

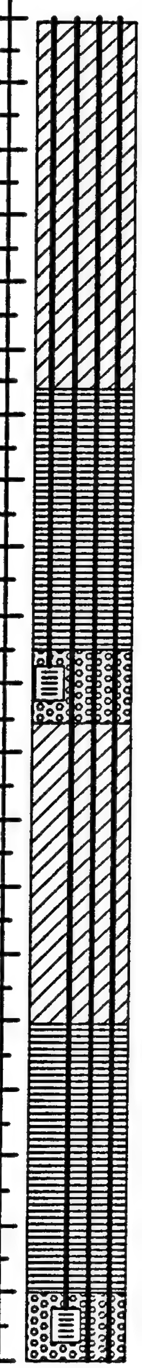


Nellis AFB – Bioventing Pilot Study		PAGE 2 OF 4	
WELL NUMBER	NE3-MPB	LOCATION	15' N of NE3-MPA
DATE	1-19-94	WEATHER	Clear, Calm – 50°F Midnight Drilling
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0'-60' 1.5" S/S 30',40',50' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING	TYPE 0.25" ID PVC	DIAMETER 0.5"	LENGTH 30',40',50' & 60'	HOLE DIA. 8"
SCREEN	TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 60'

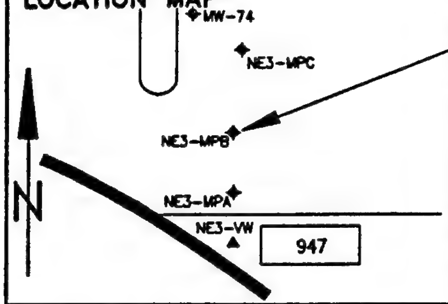
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
damp		soft	sl plas -non		110	20–21	1.25	3, 6, 3	0.00'-1.25' CLAY, pale brown, some silt, trace of fine- and very fine-grained sand. (CL)
damp		soft	sl plas		65	25–26	1.50	3, 4, 7	0.00'-0.40' CLAY, pale brown, little silt and very fine grained sand, caliche nodules at 0.4'. (CL)
damp	poor	loose	non						0.40'-1.50' SAND AND CLAY, light yellowish brown, some silt, fine- and very fine-grained sand. (SC)
damp-moist		soft	sl plas	NE3-MPB-30	62	30–31	1.50	2, 2, 4	0.00'-0.50' Cavings. 0.50'-1.50' CLAY, light yellowish brown, little silt, trace of fine- and very fine-grained sand. (CL)
moist		soft	sl plas		130	35–36	0.55	50=3.5"	0.00'-0.35' CLAY, as above.
dry		loose	non						0.35'-0.55' SILT, light brown, partially cemented, consistency of flour. (ML)

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP

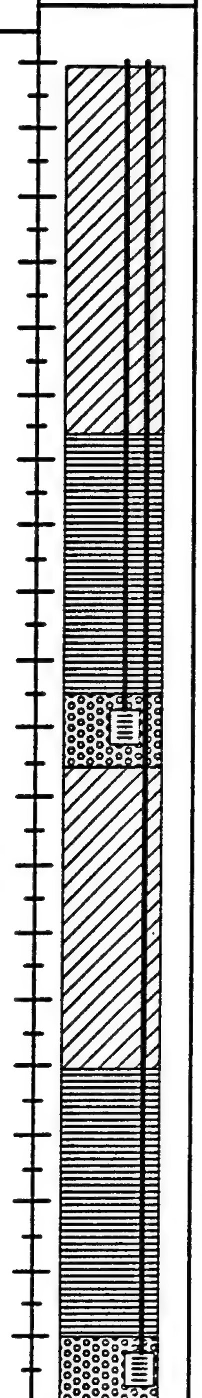


WELL NUMBER	NE3–MPB	LOCATION	15' N of NE3–MPA
DATE	1–19–94	WEATHER	Clear, Calm – 50°F Midnight Drilling
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4–1/4" ID Hollow–stem Auger	SAMPLING METHOD	0'–60' 1.5" S/S 30',40',50' 2.0" S/S
GRAVEL PACK	Colorado Silica #6–9	SEAL	Holeplug 1/4" Bentonite

CASING	TYPE 0.25" ID PVC		DIAMETER 0.5"	LENGTH 30',40',50' & 60'	HOLE DIA. 8"
SCREEN	TYPE Sch 40 PVC	SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 60'

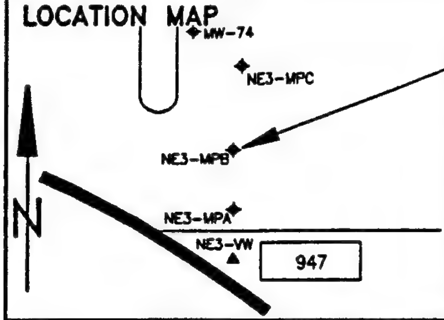
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
damp–moist		stiff	plas	NE3–MPB–40	115	40–41	1.50	11 / 25 / 25	0.00'–1.50' CLAY, light yellowish brown, some silt and very fine–grained sand. (CL)
dry damp		hard m stiff	x hard plas		180	45–46	1.50	10 / 7 / 7	0.00'–0.72' CALICHE, pale brown to white. 0.72'–1.50' CLAY, light yellowish brown, some silt and very fine–grained sand. (CL)
moist –wet	mod	dnes	sl plas	NE3–MPB–50	6200	50–51	1.50	12 / 29 / 40	0.00'–0.50' Cavings. 0.50'–1.50' SAND AND CLAY, light yellowish brown, fine–grained, little very fine–grained sand. (SC)
damp		stiff	v plas		9500	55–56	1.50	7 / 50=3"	0.00'–1.50' CLAY, pale brown, little silt and very fine–grained sand, caliche in sampler shoe. (CH)

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



WELL NUMBER	NE3-MPB	LOCATION	15' N of NE3-MPA
DATE	1-19-94	WEATHER	Clear, Calm – 50°F Midnight Drilling
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0'-60' 1.5" S/S 30',40',50' 2.0" S/S
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING TYPE 0.25" ID PVC — DIAMETER 0.5" — LENGTH 30',40',50' & 60' — HOLE DIA. 8"

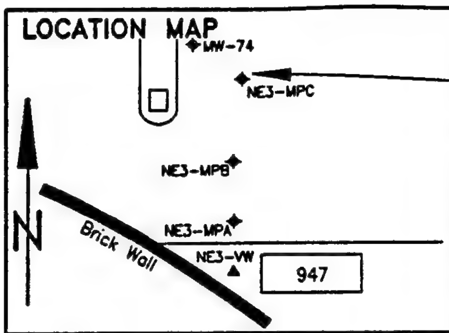
SCREEN TYPE Sch 40 PVC — SLOT 0.040" — DIAMETER 1" — LENGTH 6" — TOTAL DEPTH 60'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS	WELL COMPLETION
moist		m stiff	plas			60			0.00'-1.50' CLAY, light yellowish brown, some silt and very fine-grained sand. (CL)	
						61				
						62				
						63				
						64				
						65				
						66				
						67				
						68				
						69				
						70				
						71				
						72				
						73				
						74				
						75				
						76				
						77				
						78				
						79				
						80				

EXPLANATION: GROUT — SAND — SCREEN — HOLEPLUG — BENTONITE — CASING — WATER LEVEL

Nellis AFB – Bioventing Pilot Study		PAGE 1 OF 4
WELL NUMBER ▶ NE3-MPC	LOCATION ▶ 25' N of NE3-MPB	
DATE ▶ 1-19-94	WEATHER ▶ Clear, Calm 60°F	
LOGGED BY ▶ S. Pearson	DRILLED BY ▶ EnviroDrill	
DRILLING METHOD ▶ 4-1/4" ID Hollow-stem Auger	SAMPLING METHOD ▶ 0'-50' 1.5" Split Spoon	
GRAVEL PACK ▶ Colorado Silica #6-9	SEAL ▶ Holeplug 1/4" Bentonite	

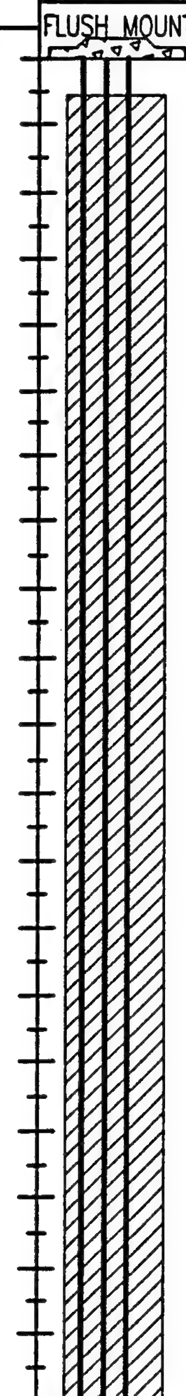
LOCATION MAP



CASING ▶ TYPE 0.25" ID PVC		DIAMETER 0.5"	LENGTH 30',40',50' & 60'	HOLE DIA. 8"
SCREEN ▶ TYPE Sch 40 PVC	SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 50'

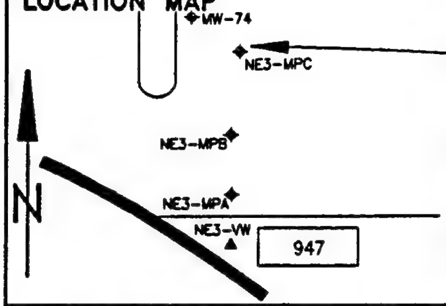
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
						0			
						1			
						2			
						3			
						4			
						5			
						6			
						7			
						8			
						9			
						10			No Recovery.
						11			
						12			
						13			13.5'-16' Driller reports caliche. Hard Drilling.
						14			
						15			
						16			
						17			
						18			
						19			
						20			

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP

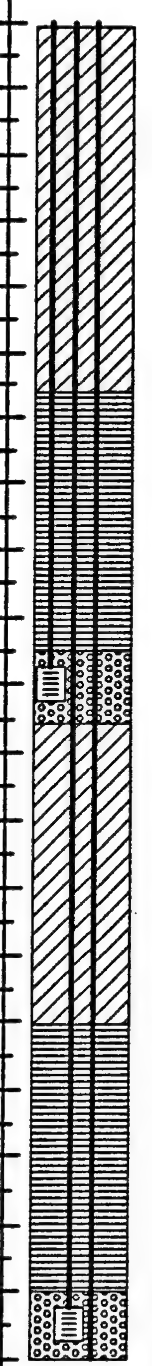


Nellis AFB – Bioventing Pilot Study			PAGE 2 OF 4
WELL NUMBER	NE3-MPC	LOCATION	25' N of NE3-MPB
DATE	1-19-94	WEATHER	Clear, Calm 60°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4-1/4" ID Hollow-stem Auger	SAMPLING METHOD	0'-50' 1.5" Split Spoon
GRAVEL PACK	Colorado Silica #6-9	SEAL	Holeplug 1/4" Bentonite

CASING	TYPE 0.25" ID PVC	DIAMETER 0.5"	LENGTH 30',40',50' & 60'	HOLE DIA. 8"
SCREEN	TYPE Sch 40 PVC SLOT 0.040"	DIAMETER 1"	LENGTH 6"	TOTAL DEPTH 50'

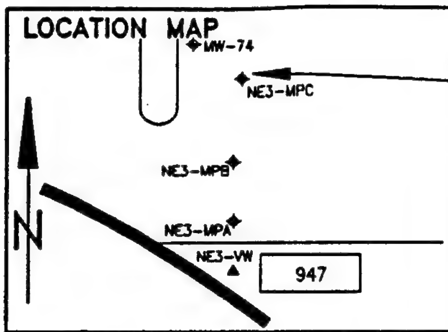
MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
						20		5	
dry		m dense	non		4300		0.74	9	0.00'-0.42' Cavings. 0.42'-0.65' CLAY, SILT AND SAND, pale brown, very fine-grained. (SC)
dry		hard	x hard			21		10	0.65'-0.74' CALICHE, white, massive.
						22			
						23			
						24			
damp	poor	loose-m dense	non-pl plas			25		7	0.21'-1.50' CLAY AND SAND, light yellowish brown, fine- and very fine-grained, some silt. (SC)
					1500	26	1.50	7	
								9	
						27			
						28			
						29			
						30		3	No Recovery–CALICHE. Headspace sample collected from cuttings.
					2000	31	NA	6	
								10	
						32			
						33			
						34			
dry	poor	hard	non			35		50=4"	0.00'-0.21' Cavings.
dry	poor	hard	non		110	36	0.48		0.21'-0.48' SAND, light brown, very fine-grained, some silt and fine-grained sand, trace of clay, cemented. (SM)
						37			
						38			
						39			
						40			

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

LOCATION MAP



Nellis AFB – Bioventing Pilot Study

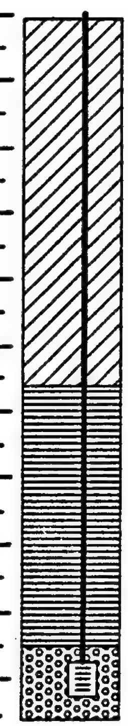
WELL NUMBER	NE3–MPC	LOCATION	25' N of NE3–MPB
DATE	1–19–94	WEATHER	Clear, Calm 60°F
LOGGED BY	S. Pearson	DRILLED BY	EnviroDrill
DRILLING METHOD	4–1/4" ID Hollow–stem Auger	SAMPLING METHOD	0'–50' 1.5" Split Spoon
GRAVEL PACK	Colorado Silica #6–9	SEAL	Holeplug 1/4" Bentonite

CASING TYPE 0.25" ID PVC DIAMETER 0.5" LENGTH 30',40',50' & 60' HOLE DIA. 8"

SCREEN TYPE Sch 40 PVC SLOT 0.040" DIAMETER 1" LENGTH 6" TOTAL DEPTH 50'

MOISTURE CONTENT	SORTING	DENSITY	PLASTICITY	SAMPLE NUMBER	TIP READING (PPM)	DEPTH	SAMPLE RECOVERY	PENETRATION RESISTANCE	LITHOLOGY/REMARKS
dry	poor	dense	non		70	40	1.08	95 / 23 / 37	0.00'–0.46' Cavings. 0.46'–1.08' SAND AND SILT, light brown, fine- and very fine-grained, cemented. (SM)
damp	mod	dense	sl plas			41			1.08'–1.50' SAND, light yellowish brown, fine- and very fine-grained, little silt and clay, (SM)
						42			
						43			
						44			
dry	poor	dense	non		140	45	1.49	40 / 31 / 20	0.00'–0.49' SILT AND SAND, light brown, fine- and very fine-grained sand, trace of clay. (SM)
						46			
						47			
						48			
						49			
wet		soft	sl plas		>10,000	50	1.50	5 / 16 / 26	0.00'–0.21' CLAY, light yellowish brown, trace of silt and very fine-grained sand. (CL)
wet		m stiff	sl plas			51			0.21'–1.50' CLAY, SILT AND SAND, grayish white, very fine-grained, trace of caliche pebbles, interbedded massive caliche. (SC)
						52			
						53			Encounter groundwater between 51.5' and 55'
						54			
						55			No Recovery–Saturated sample fell from sampler.
						56			
						57			
						58			
						59			
						60			

WELL COMPLETION



EXPLANATION: GROUT, SAND, SCREEN, HOLEPLUG, BENTONITE, CASING, WATER LEVEL

AIR TOXICS LTD.
AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630
(916) 985-1000 • FAX (916) 985-1020

CHAIN OF CUSTODY RECORD

PROJECT # 722408.50040 PO # 722408.50090 COLLECTED BY (Signature) [illegible]
REMARKS NELLIS AFB - BIOVENTING - THREE SITES [illegible]

	FIELD SAMPLE I.D.#	SAMPLING MEDIA (Tenax, Canister etc.)	DATE/TIME	ANALYSIS	VAC./PRESSURE	LAB I.D. #
01A	NE3-MPA-50	CANISTER (SUMMA)	1/26/94 / 0727	TO-3 (BTEX/TPH)	0.5" Hg	
02A	NE2-VW	↓	1/25/94 - 1151	↓	2.0" Hg	
03A	NE2-MPC-39	↓	1/25/94 - 1507	↓	1.5" Hg	
04A	NE1-MPA-55	↓	1/26/94 - 0932	↓	0.5" Hg	
05A	NE1-MPC-70	↓	1/25/94 - 1021	↓	1.0" Hg	
06A	NE1-VW	↓	1/25/94 - 0858	↓	0.5" Hg	
07AB	NE3-MPC-30	↓	1/26/94 - 0831	↓	1.5" Hg	
08A	NE2-MPA-32	↓	1/25/94 - 1425	↓	2.0" Hg	
09A	NE3-VW	↓	1/25/94 - 1609	↓	2.0" Hg	

RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME	RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME
[illegible] 1/26/94 / 1630	FED EX 1/26/94 / 1630	→	[illegible] ATL 1/27/94 16:15

LAB USE ONLY

SHIPPER NAME	AIR BILL #	OPENED BY: DATE/TIME	TEMP(°C)	CONDITION

REMARKS Custody seals not present [illegible]

740117.502

CHAIN OF CUSTODY RECORD

ENGINEERING-SCIENCE, INC.
1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290
303-831-8100

ES Job No. 722408.50080
~~DE268. ___ .08~~

AFCEE BIOVENTING PILOT TESTS

Base: NELLIS AFB, LAS VEGAS, NEVADA

Site: SITE 27

Sampler(s): (Signature)
RUSSELL FRISHMUTH: Russell Frishmuth
Scott Pearson x Scott Pearson

Preservative: NONE (SW 9045, A 403, SW 7380, SW 846); HOLD AT 4C (SW 8020, E 418.1); NONE (E 351.2, E 365.3, UCM)

Analysis Required

Date	Time	Sample Description	Lab I.D.	No. of Contrs.	SW 9045 (PH)	A 403 (ALKA)	SW 7380 (IRON)	SW 846 (MOIST)	SW 8020 (BTEX)	E 418.1 (TRPH)	E 351.2 (TKN)	E 365.3 (PHOS)	UCM (CLASS)	Sample Type	Matrix	Remarks
1/13/94	1104	NE1-VW-80		3	X	X	X	X	X	X	X	X	X	G C	SOIL	
1/14/94	0945	NE1-MPA-65		3	X	X	X	X	X	X	X	X	X	G C	SOIL	
1/15/94	0745	NE1-MPB-70		3	X	X	X	X	X	X	X	X	X	G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
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														G C	SOIL	
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														G C	SOIL	
														G C	SOIL	
														G C	SOIL	

Ship To:
PACE INCORPORATED
5702 Bolsa Ave.
Huntington Beach, CA 92649

Attn: Melony Concepcion
(714) 892-2565

Relinquished by: (Signature)	Date / Time		Recieved for Laboratory by: (Signature)	Date / Time	
Russell Frishmuth	1/15/94	1300	FED EX	1/15/94	1300
S. [illegible] for FEDEX	1-17-94	9:30	S. [illegible] Pace	1-17-94	9:30

Remarks: Recd @ 3.0°C. [illegible] 1-17-94

G - Grab Sample, C - Composite Sample

Distribution: Original Accompanies Shipment. Copies to: Coordinator Field Files
Federal Express Number:
Airbill Number: 1968961330

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1700 Broadway, Suite 900 • Denver, Colorado
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CCRSOIL

740120, 303

CHAIN OF CUSTODY RECORD

ENGINEERING-SCIENCE, INC.
1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290
303-831-8100

ES Job No. 722408.50080
~~DE268. ___ .08~~

AFCEE BIOVENTING PILOT TESTS

Base: NELLIS AFB, LAS VEGAS, NV

Site: SITE 44
SITE 27

Sampler(s): (Signature)
RUSSELL FRISHMUTH : Russell [signature]
SCOTT PEARSON : Scott Pe[signature]

Ship To:

PACE INCORPORATED
5702 Bolsa Ave.
Huntington Beach, CA 92649

Attn: Melony Concepcion
(714) 892-2565

Preservative: NONE (SW 9045, A 403, SW 7380, SW 846); HOLD AT 4C (SW 8020, E 418.1); NONE (E 351.2, E 365.3, UCM)

Analysis Required

Date	Time	Sample Description	Lab I.D.	No. of Contrs.	SW 9045 (PH)	A 403 (ALKA)	SW 7380 (IRON)	SW 846 (MOIST)	SW 8020 (BTEX)	E 418.1 (TRPH)	E 351.2 (TKN)	E 365.3 (PHOS)	UCM (CLASS)	Sample Type	Matrix	Remarks
1/15/94	1305	NE1-MPC-65		3	X	X	X	X	X	X	X	X	X	G C	SOIL	
1/16/94	1640	NE2-VW-40		3	X	X	X	X	X	X	X	X	X	G C	SOIL	
1/17/94	1520	NE2-MPA-32		3	X	X	X	X	X	X	X	X	X	G C	SOIL	
1/17/94	1636	NE2-MPB-24		3	X	X	X	X	X	X	X	X	X	G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	

Relinquished by: (Signature)	Date / Time	Recieved for Laboratory by: (Signature)	Date / Time
Russell [signature]	1/15/94 1500	FED EX	1/15/94 1500
VIA FED EX	1-20 0950	[signature] PACE	1-20 0950

Remarks: CUSTODY SEAL INTACT, RECD @T 5.0° 6U

G - Grab Sample, C - Composite Sample

Distribution: Original Accompanies Shipment. Copies to: Coordinator Field Files

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1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290
303-831-8100

AFCEE BIOVENTING PILOT TESTS

Base: NELLIS AFB, LAS VEGAS NV

Site: SITE ZB

ES Job No. ~~DE268.~~ 08 722408.50080

Sampler(s): (Signature) Russell Frishmuth : [signature] Scott Pearson: [signature]

Ship To:
PACE INCORPORATED
5702 Bolsa Ave.
Huntington Beach, GA 92649

Attn: Melony Concepcion
(714) 892-2565

Preservative: NONE (SW 9045, A 403, SW 7380, SW 846); HOLD (SW 8020); AT 4C (E 418.1); NONE (E 351.2, E 365.3, UCM)

Analysis Required

Date	Time	Sample Description	Lab I.D.	No. of Contrs.	SW 9045 (PH)	A 403 (ALKA)	SW 7380 (IRON)	SW 846 (MOIST)	SW 8020 (BTEX)	E 418.1 (TRPH)	E 351.2 (TKN)	E 365.3 (PHOS)	UCM (CLASS)	Sample Type	Matrix	Remarks
1/19	1334	NES-YN-65		3	X	X	X	X	X	X	X	X	X	G C	SOIL	243.4
1/20	0003	NES-MPB-50		3	X	X	X	X	X	X	X	X	X	G C	SOIL	244.2
1/20	1907	NES-MPA-42		3	X	X	X	X	X	X	X	X	X	G C	SOIL	245.0
1/19	2345	NES-MPB-30		2					X	X	X			G C	SOIL	246.9
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	
														G C	SOIL	

Relinquished by: (Signature)	Date / Time	Recieved for Laboratory by: (Signature)	Date / Time
[signature]	1/21 1700	FED EX	1/21 1700
S. Pearson for FEDEX.		[signature] / Pace.	1-22-94 10:15

Remarks: Recd @ 3.1° [initials] 1-22-94

G - Grab Sample, C - Composite Sample

Distribution: Original Accompanies Shipment. Copies to: Coordinator Field Files

Federal Express Number:
Airbill Number: 1968961282

ENGINEERING-SCIENCE, INC.
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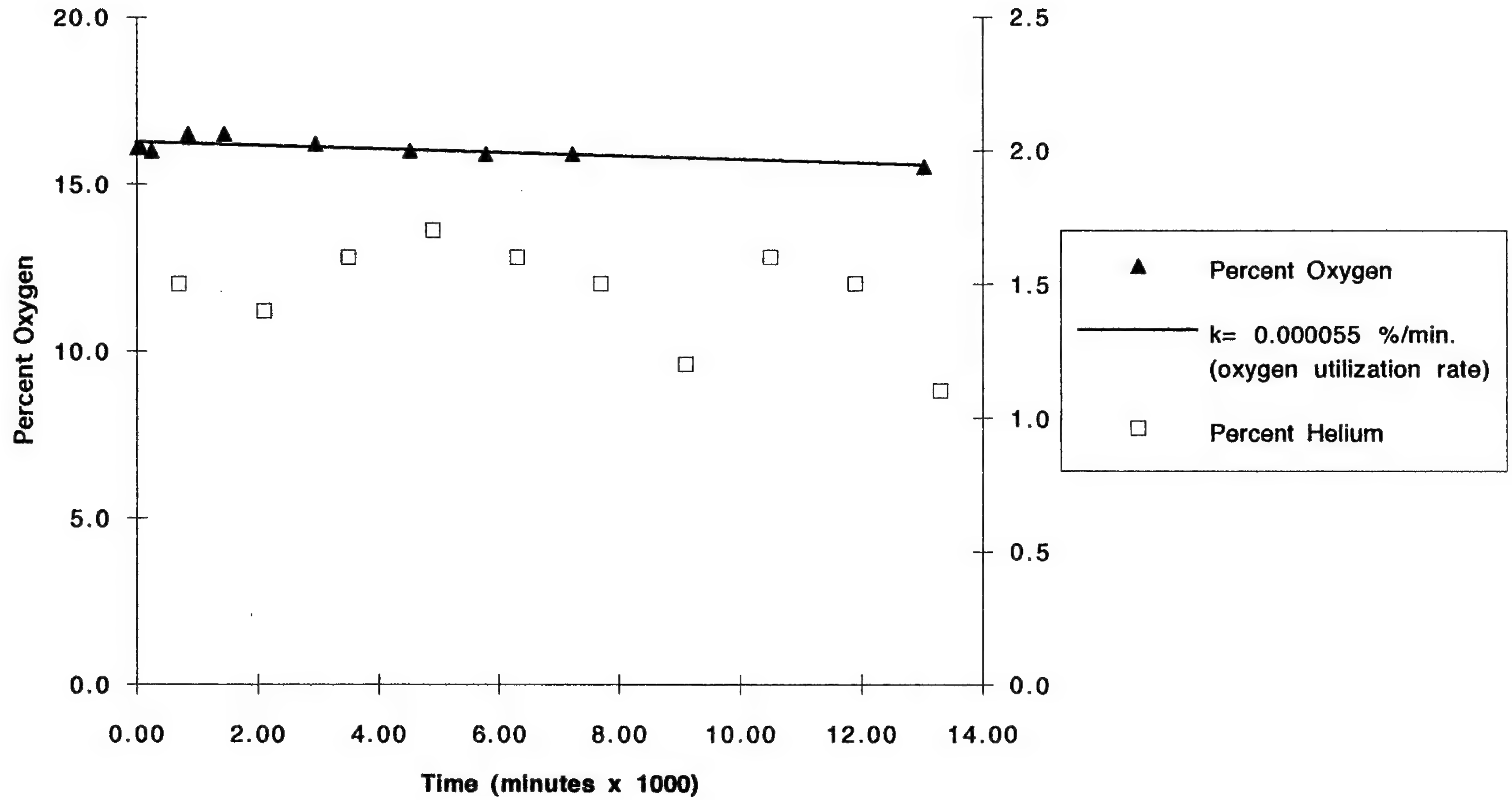
CCRSOIL

Respiration Test
Site 27
Nellis AFB, Nevada

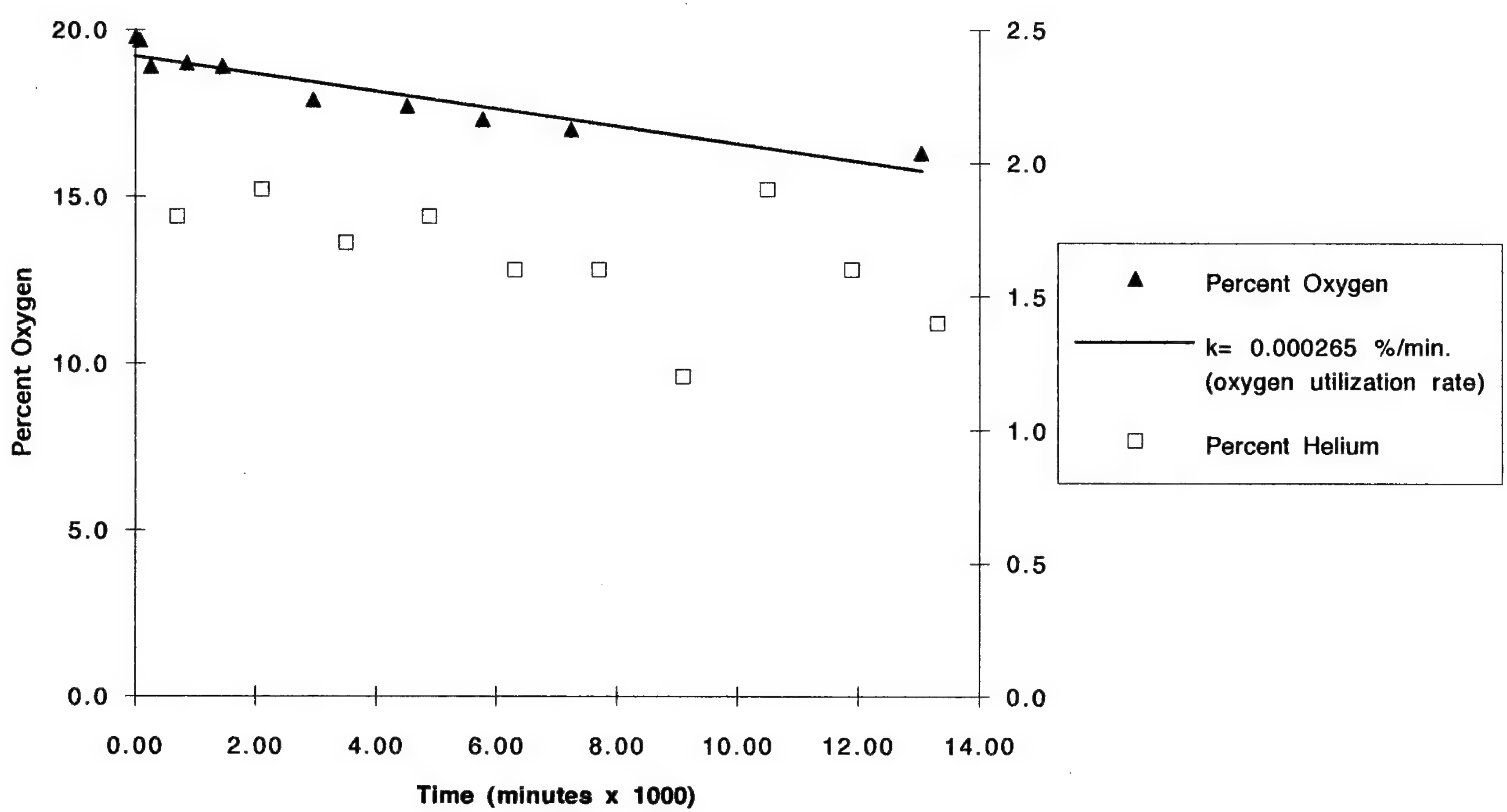
Monitoring Point	Date	Days Elapsed (frac. days)	Time	Hrs elapsed (fractional days)	Days Elapsed	Elapsed Time (min. x 1000)	O2%	CO2%	Total Hydro-carbon	Helium	Comments	Trend of O2/ Time	New x-values	k
VW	01/27/94	0.00	08:14	0.00	0.00	0.00	20.6	0.50	4,800	2.1	Begin Respiration Test.	19.168388	0	0.003761
VW	01/27/94	0.00	09:14	0.04	0.04	0.06	19.2	0.50	6,600	1.9		11.722534	1.98	
VW	01/27/94	0.00	12:14	0.17	0.17	0.24	17.5	0.60	9,200	1.7				
VW	01/27/94	0.00	17:14	0.38	0.38	0.54	16.2	0.90	13,600	1.7				
VW	01/27/94	0.00	22:14	0.58	0.58	0.84	15.8	1.00	15,600	1.7				
VW	01/28/94	1.00	08:14	0.00	1.00	1.44	13.0	1.50	19,200	1.7				
VW	01/28/94	1.00	17:14	0.38	1.38	1.98	12.7	1.75	19,200	1.4				
VW	01/29/94	2.00	09:14	0.04	2.04	2.94	11.6	2.00	>20,000	1.7				
VW	01/29/94	2.00	17:17	0.38	2.38	3.42	12.2	2.00	>20,000	1.6				
VW	01/30/94	3.00	11:14	0.13	3.13	4.50	11.2	2.50	>20,000	1.3				
VW	01/31/94	4.00	08:14	0.00	4.00	5.76	10.2	2.60	>20,000	1.6				
VW	02/01/94	5.00	08:30	0.01	5.01	7.22	10.7	2.50	>20,000	1.5				
VW	02/05/94	9.00	09:19	0.05	9.05	13.03	9.9	3.30	>20,000	1.4				
MPA-70	01/27/94	0.00	08:20	0.00	0.00	0.01	20.2	0.20	6,400	2.0		19.871905	0	0.000488
MPA-70	01/27/94	0.00	09:19	0.05	0.05	0.07	20.0	0.20	14,200	2.1		16.34955	7.22	
MPA-70	01/27/94	0.00	12:19	0.17	0.17	0.25	19.5	0.20	16,000	1.8				
MPA-70	01/27/94	0.00	22:20	0.59	0.59	0.85	19.4	0.35	20,000	1.9				
MPA-70	01/28/94	1.00	08:19	0.00	1.00	1.45	19.1	0.45	>20,000	1.9				
MPA-70	01/29/94	2.00	09:19	0.05	2.05	2.95	18.2	0.60	>20,000	1.8				
MPA-70	01/30/94	3.00	11:30	0.14	3.14	4.52	17.7	0.60	>20,000	1.3				
MPA-70	01/31/94	4.00	08:19	0.00	4.00	5.77	17.0	0.75	>20,000	1.9				
MPA-70	02/01/94	5.00	08:35	0.01	5.01	7.22	16.5	0.60	>20,000	1.3				
MPA-70	02/05/94	9.00	09:25	0.05	9.05	13.03	16.5	0.60	>20,000	1.3				
MPA-55	01/27/94	0.00	08:23	0.01	0.01	0.01	16.1	10.10	12,800	1.5		16.267884	0	5.48E-05
MPA-55	01/27/94	0.00	09:22	0.05	0.05	0.07	16.1	10.50	11,400	1.4		15.553857	13.03	
MPA-55	01/27/94	0.00	12:22	0.17	0.17	0.25	16.0	10.50	10,000	1.6				
MPA-55	01/27/94	0.00	22:23	0.59	0.59	0.85	16.5	10.50	10,000	1.7				
MPA-55	01/28/94	1.00	08:22	0.01	1.01	1.45	16.5	10.90	10,000	1.6				
MPA-55	01/29/94	2.00	09:22	0.05	2.05	2.95	16.2	10.40	10,000	1.5				
MPA-55	01/30/94	3.00	11:27	0.13	3.13	4.51	16.0	11.00	11,400	1.2				
MPA-55	01/31/94	4.00	08:23	0.01	4.01	5.77	15.9	10.90	12,000	1.6				
MPA-55	02/01/94	5.00	08:39	0.02	5.02	7.23	15.9	10.90	12,000	1.5				
MPA-55	02/05/94	9.00	09:28	0.05	9.05	13.03	15.5	10.90	12,400	1.1				
MPB-70	01/27/94	0.00	08:27	0.01	0.01	0.01	19.8	1.00	>20,000	1.8		19.208583	0	0.000265
MPB-70	01/27/94	0.00	09:27	0.05	0.05	0.07	19.7	0.80	>20,000	1.9		15.751936	13.04	
MPB-70	01/27/94	0.00	12:26	0.18	0.18	0.25	18.9	0.70	>20,000	1.7				
MPB-70	01/27/94	0.00	22:29	0.59	0.59	0.86	19.0	0.80	>20,000	1.8				
MPB-70	01/28/94	1.00	08:26	0.01	1.01	1.45	18.9	0.80	>20,000	1.6				
MPB-70	01/29/94	2.00	09:28	0.05	2.05	2.95	17.9	0.90	>20,000	1.6				
MPB-70	01/30/94	3.00	11:36	0.14	3.14	4.52	17.7	0.90	>20,000	1.2				
MPB-70	01/31/94	4.00	08:27	0.01	4.01	5.77	17.3	0.90	>20,000	1.9				
MPB-70	02/01/94	5.00	08:44	0.02	5.02	7.23	17.0	0.90	>20,000	1.6				
MPB-70	02/05/94	9.00	09:32	0.05	9.05	13.04	16.3	0.90	>20,000	1.4				

MPB-55	01/27/94	0.00	08:31	0.01	0.01	0.02	20.6	0.10	440	2.2		20.297627	0	0.000535	
MPB-55	01/27/94	0.00	09:31	0.05	0.05	0.08	20.1	0.20	760	2.2		18.432975	7.23		
MPB-55	01/27/94	0.00	12:30	0.18	0.18	0.26	19.8	0.09	1,160	2.1					
MPB-55	01/27/94	0.00	22:32	0.60	0.60	0.86	19.9	0.20	2,400	2.1					
MPB-55	01/28/94	1.00	08:30	0.01	1.01	1.46	19.8	0.50	3,200	2.0					
MPB-55	01/29/94	2.00	09:32	0.05	2.05	2.96	18.6	0.60	5,400	1.8					
MPB-55	01/30/94	3.00	11:40	0.14	3.14	4.53	18.0	0.70	7,000	1.3					
MPB-55	01/31/94	4.00	08:30	0.01	4.01	5.78	16.9	0.80	8,800	1.6					
MPB-55	02/01/94	5.00	08:48	0.02	5.02	7.23	16.6	0.95	11,000	1.5					
MPB-55	02/05/94	9.00	09:35	0.06	9.06	13.04	15.4	1.10	10,600	1.2					
MPC-70	01/27/94	0.00	08:36	0.02	0.02	0.02	20.0	0.80	>20,000	1.7		19.076459	0	0.000286	
MPC-70	01/27/94	0.00	09:36	0.06	0.06	0.08	19.1	0.90	>20,000	1.7		15.347551	13.04		
MPC-70	01/27/94	0.00	12:35	0.18	0.18	0.26	18.9	0.70	>20,000	1.7					
MPC-70	01/27/94	0.00	22:37	0.60	0.60	0.86	18.8	0.80	>20,000	1.7					
MPC-70	01/28/94	1.00	08:35	0.01	1.01	1.46	18.8	0.80	>20,000	1.7					
MPC-70	01/29/94	2.00	09:37	0.06	2.06	2.96	17.6	0.90	>20,000	1.6					
MPC-70	01/30/94	3.00	11:45	0.15	3.15	4.53	17.4	0.80	>20,000	1.1					
MPC-70	01/31/94	4.00	08:37	0.02	4.02	5.78	17.0	0.80	>20,000	1.8					
MPC-70	02/01/94	5.00	08:52	0.03	5.03	7.24	17.0	0.80	>20,000	1.5					
MPC-70	02/05/94	9.00	09:35	0.06	9.06	13.04	15.8	0.80	>20,000	1.2					
MPC-55	01/27/94	0.00	08:39	0.02	0.02	0.03	20.5	0.20	760	2.1		19.992636	0	0.000144	
MPC-55	01/27/94	0.00	09:39	0.06	0.06	0.09	20.0	0.30	1,000	2.3		18.112805	13.05		
MPC-55	01/27/94	0.00	12:39	0.18	0.18	0.27	19.0	0.20	1,600	2.1					
MPC-55	01/27/94	0.00	22:41	0.60	0.60	0.87	20.0	0.70	3,600	2.3					
MPC-55	01/28/94	1.00	08:38	0.02	1.02	1.46	20.0	0.80	3,800	2.0					
MPC-55	01/29/94	2.00	09:40	0.06	2.06	2.97	19.5	0.90	3,600	1.7					
MPC-55	01/30/94	3.00	11:51	0.15	3.15	4.54	19.5	0.80	5,200	1.4					
MPC-55	01/31/94	4.00	08:40	0.02	4.02	5.79	19.1	1.00	6,600	1.1					
MPC-55	02/01/94	5.00	08:54	0.03	5.03	7.24	19.1	1.10	4,600	1.1					
MPC-55	02/05/94	9.00	09:41	0.06	9.06	13.05	18.0	1.50	6,600	1.2					

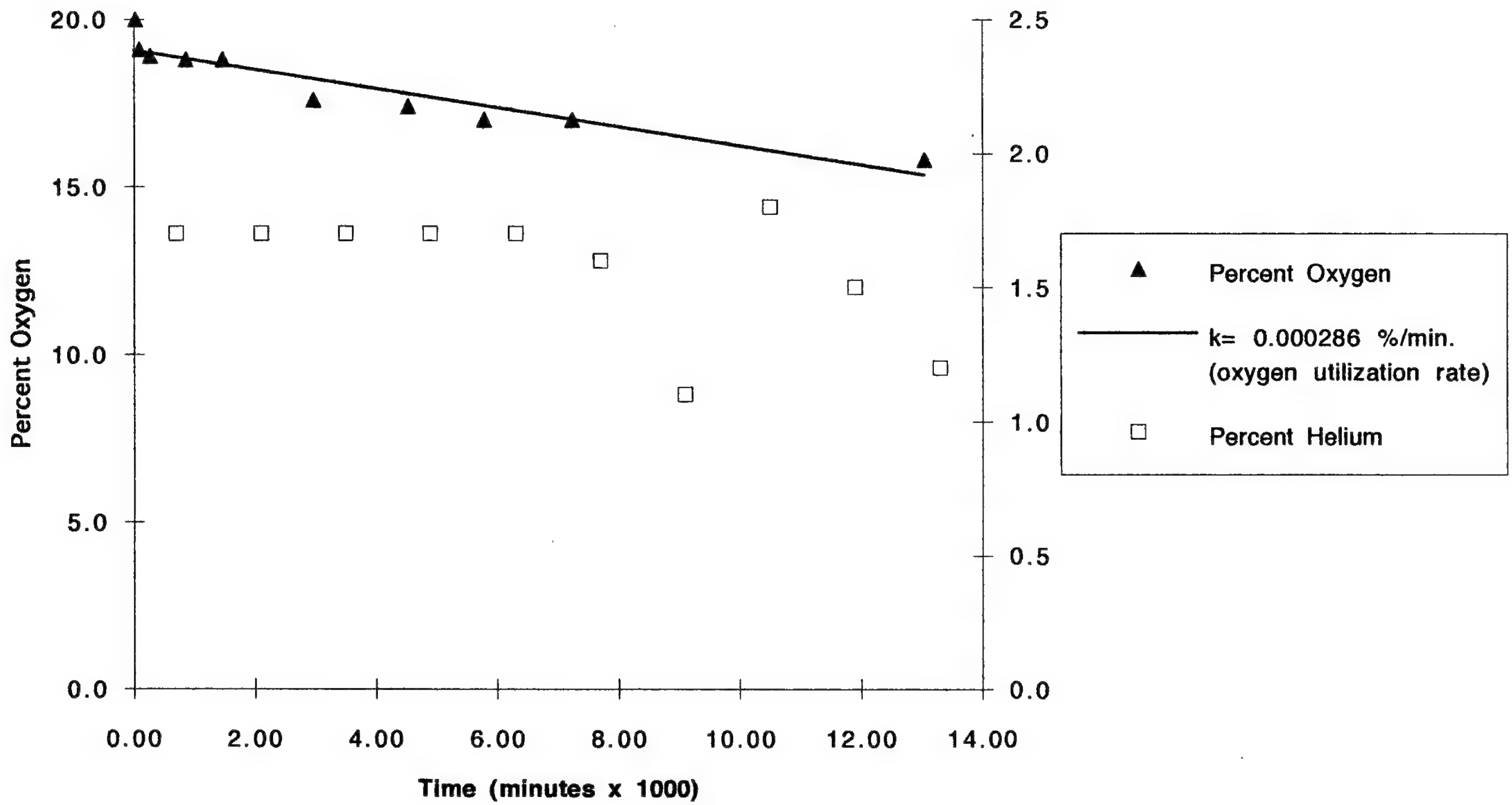
Respiration Test
Oxygen and Helium Concentrations
Site 27, MPA-55
Nellis AFB, Nevada



Respiration Test
Oxygen and Helium Concentrations
Site 27, MPB-70
Nellis AFB, Nevada



Respiration Test
Oxygen and Helium Concentrations
Site 27, MPC-70
Nellis AFB, Nevada

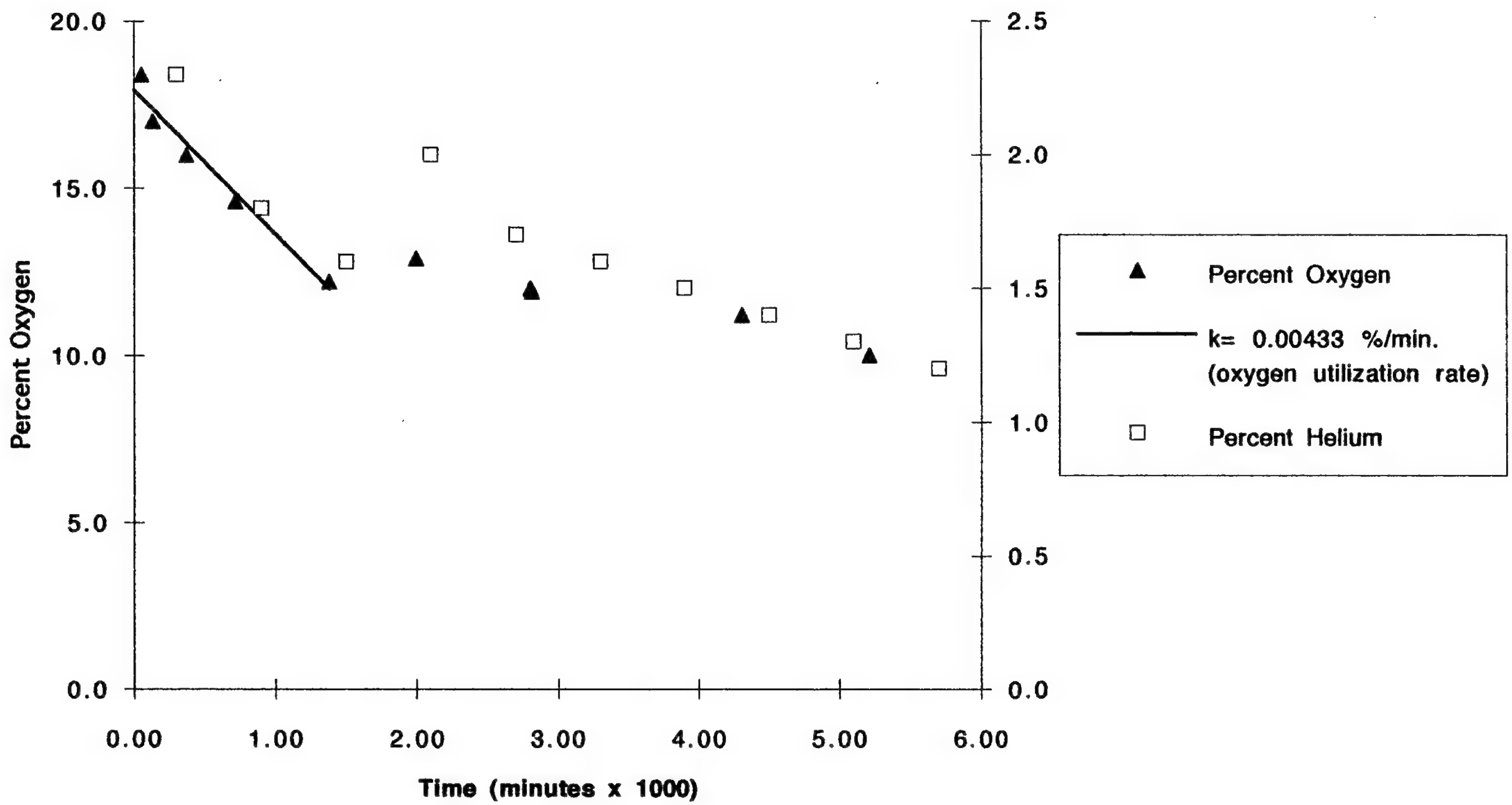


Respiration Test
Site 28
Nellis AFB, Nevada

Monitoring Point	Date	Days Elapsed (frac. days)	Time	Hrs elapsed (fractional days)	Days Elapsed	Elapsed Time (min. x 1000)	O2%	CO2%	Total Hydro-carbon	Helium	Comments	Trend of O2/ Time	New x-values	k
VW	01/30/94	0.00	08:58	0.03	0.03	0.04	19.1	2.40	13,200	2.7		19.066516	0	0.004338
VW	01/30/94	0.00	10:21	0.09	0.09	0.13	18.8	2.20	10,400	2.2		10.433596	1.99	
VW	01/30/94	0.00	14:20	0.25	0.25	0.37	16.8	2.60	14,200	2.2				
VW	01/30/94	0.00	20:01	0.49	0.49	0.71	15.8	2.30	10,400	1.9				
VW	01/31/94	1.00	06:51	-0.06	0.94	1.36	13.8	2.20	10,400	1.9				
VW	01/31/94	1.00	17:20	0.38	1.38	1.99	10.2	2.80	16,400	2.7				
VW	02/01/94	2.00	06:49	-0.06	1.94	2.80	8.4	3.00	18,000	2.5				
VW	02/01/94	2.00	16:55	0.36	2.36	3.40	7.0	3.60	>20,000	2.3				
VW	02/02/94	3.00	07:52	-0.02	2.98	4.30	6.8	4.00	>20,000	2.1				
VW	02/02/94	3.00	22:55	0.61	3.61	5.20	5.3	4.30	>20,000	2.5				
MPA-50	01/30/94	0.00	09:04	0.03	0.03	0.05	20.0	0.10	4,200	2.6		19.904756	0	0.004688
MPA-50	01/30/94	0.00	10:25	0.09	0.09	0.13	19.2	0.10	6,800	2.2		3.9202076	3.41	
MPA-50	01/30/94	0.00	14:25	0.26	0.26	0.37	17.7	0.10	6,800	0.4	Bag empty for Helium test.			
MPA-50	01/30/94	0.00	20:08	0.50	0.50	0.71	17.2	0.25	7,400	0.6	Possibly bad bag.			
MPA-50	01/31/94	1.00	06:56	-0.05	0.95	1.36	14.2	0.50	9,200	1.4				
MPA-50	01/31/94	1.00	17:25	0.38	1.38	1.99	9.0	0.60	17,000	2.1				
MPA-50	02/01/94	2.00	06:54	-0.06	1.94	2.80	6.3	0.70	19,600	2.0				
MPA-50	02/01/94	2.00	16:59	0.36	2.36	3.41	4.9	0.90	>20,000	2.0				
MPA-50	02/02/94	3.00	07:56	-0.01	2.99	4.30	3.7	1.00	>20,000	1.5				
MPA-50	02/02/94	3.00	23:03	0.62	3.62	5.21	2.8	1.10	>20,000	2.3				
MPA-40	01/30/94	0.00	09:07	0.04	0.04	0.05	18.4	4.10	3,000	2.3		17.938005	0	0.004329
MPA-40	01/30/94	0.00	10:28	0.09	0.09	0.13	17.0	6.20	5,000	1.8		11.963538	1.38	
MPA-40	01/30/94	0.00	14:28	0.26	0.26	0.37	16.0	7.30	6,800	1.6				
MPA-40	01/30/94	0.00	20:12	0.50	0.50	0.72	14.6	8.10	8,000	2.0				
MPA-40	01/31/94	1.00	07:09	-0.05	0.95	1.38	12.2	9.60	10,000	1.7				
MPA-40	01/31/94	1.00	17:28	0.38	1.38	1.99	12.9	9.10	9,200	1.6				
MPA-40	02/01/94	2.00	06:57	-0.05	1.95	2.80	12.0	9.80	10,000	1.5				
MPA-40	02/01/94	2.00	07:03	-0.05	1.95	2.81	11.9	9.70	10,200	1.4				
MPA-40	02/02/94	3.00	08:00	-0.01	2.99	4.31	11.2	9.90	8,800	1.3				
MPA-40	02/02/94	3.00	23:06	0.62	3.62	5.21	10.0	10.00	11,600	1.2				
MPB-60	01/30/94	0.00	09:15	0.04	0.04	0.06	20.2	0.20	5,600	2.2		20.76861	0	0.002961
MPB-60	01/30/94	0.00	10:34	0.10	0.10	0.14	20.2	0.20	7,200	1.5		12.447692	2.81	
MPB-60	01/30/94	0.00	14:33	0.26	0.26	0.38	20.0	0.50	12,600	1.7				
MPB-60	01/31/94	1.00	07:04	-0.05	0.95	1.37	17.0	0.95	>20,000	2.3				
MPB-60	01/31/94	1.00	17:33	0.39	1.39	2.00	15.1	1.00	>20,000	2.3				
MPB-60	02/01/94	2.00	07:03	-0.05	1.95	2.81	12.1	1.30	>20,000	1.9				
MPB-60	02/01/94	2.00	17:07	0.37	2.37	3.41	12.0	1.50	>20,000	1.9				
MPB-60	02/02/94	3.00	08:05	-0.01	2.99	4.31	12.8	1.80	>20,000	1.9				
MPB-60	02/02/94	3.00	23:13	0.62	3.62	5.22	12.1	2.00	>20,000	2.1				
MPC-40	01/30/94	0.00	09:36	0.06	0.06	0.08	20.3	0.20	2,600	2.6		20.797747	0	0.000875
MPC-40	01/30/94	0.00	10:37	0.10	0.10	0.14	20.3	0.08	440	2.3		16.231806	5.22	
MPC-40	01/30/94	0.00	14:36	0.27	0.27	0.38	20.3	0.15	520	2.2				
MPC-40	01/31/94	1.00	07:13	-0.04	0.96	1.38	20.1	0.10	1,400	2.6				
MPC-40	01/31/94	1.00	17:37	0.39	1.39	2.00	19.6	0.20	3,600	2.4				

MPC-40	02/01/94	2.00	07:06	-0.05	1.95	2.81	18.9	0.20	2,800	2.0					
MPC-40	02/01/94	2.00	17:11	0.37	2.37	3.42	17.7	0.20	2,800	1.6					
MPC-40	02/02/94	3.00	08:08	0.00	3.00	4.31	17.0	0.20	5,800	1.7					
MPC-40	02/02/94	3.00	23:17	0.63	3.63	5.22	15.7	0.40	5,600	1.3					

Respiration Test
Oxygen and Helium Concentrations
Site 28, MPA-40
Nellis AFB, Nevada

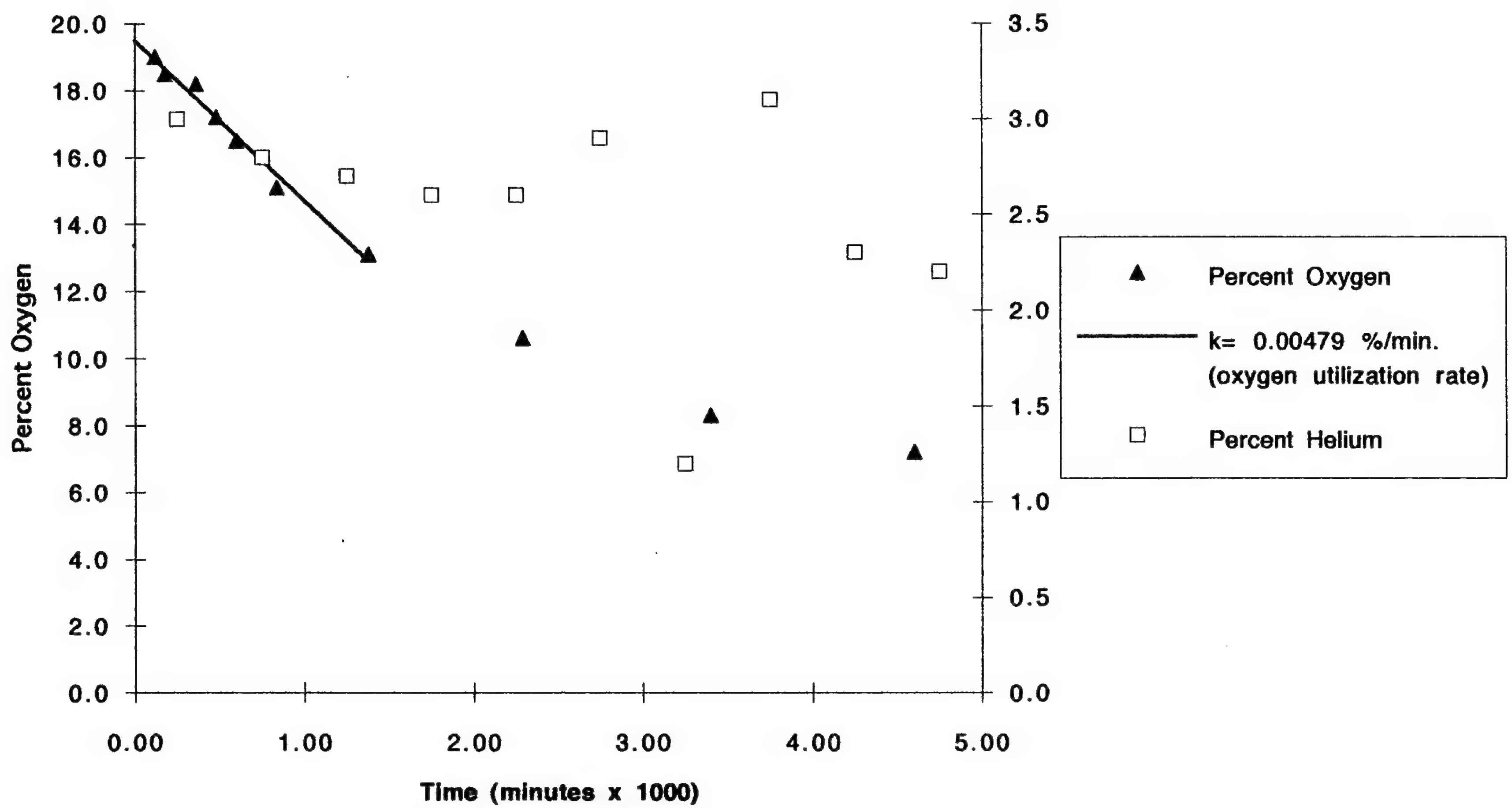


Respiration Test
Site 44
Nellis AFB, Nevada

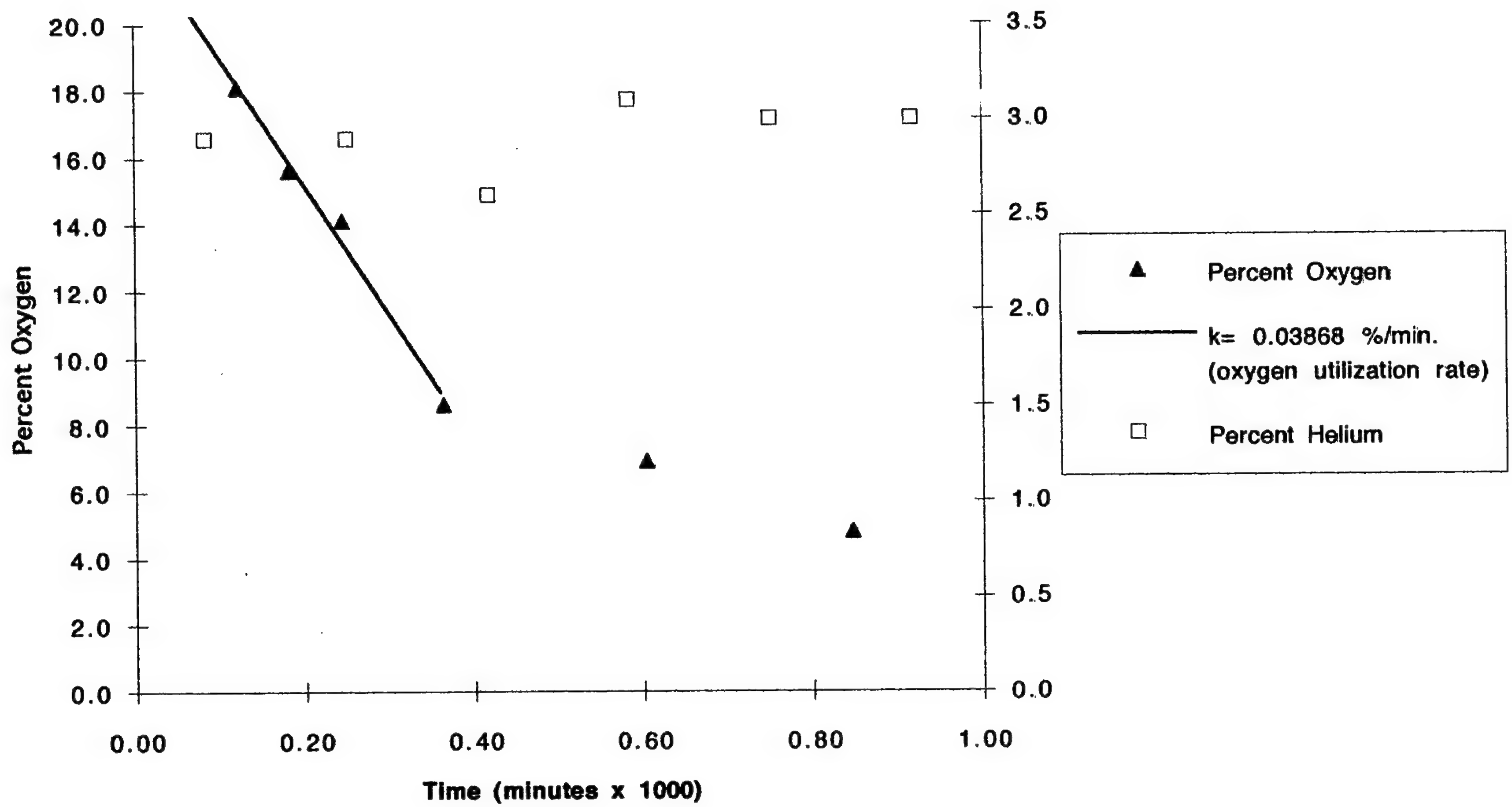
Monitoring Point	Date	Days Elapsed (frac. days)	Time	Hrs elapsed (fractional days)	Days Elapsed	Elapsed Time (min. x 1000)	O2%	CO2%	Total Hydro-carbon	Helium	Comments	Trend of O2/ Time	New x-values	k
VW	02/01/94	0.00	10:05	0.08	0.08	0.11	19.9	0.50	2,400	2.6	Begin Respiration Test.	20.614659	0	0.008158
VW	02/01/94	0.00	11:07	0.12	0.12	0.17	19.4	0.60	3,200	3.0		13.84376	0.83	
VW	02/01/94	0.00	14:09	0.25	0.25	0.36	17.2	0.90	4,000	3.0				
VW	02/01/94	0.00	16:06	0.33	0.33	0.47	16.7	1.00	4,000	2.6				
VW	02/01/94	0.00	18:06	0.41	0.41	0.59	15.8	1.20	4,000	2.7				
VW	02/01/94	0.00	22:07	0.58	0.58	0.83	14.0	1.70	4,200	3.1				
VW	02/02/94	1.00	08:07	0.00	1.00	1.43	12.6	2.20	4,000	2.3				
VW	02/02/94	1.00	22:17	0.59	1.59	2.28	11.0	2.60	5,800	2.9				
VW	02/03/94	2.00	16:46	0.36	2.36	3.39	9.3	3.30	6,400	2.5				
VW	02/04/94	3.00	12:51	0.19	3.19	4.60	8.3	4.00	6,400	2.8				
MPA-32	02/01/94	0.00	10:08	0.08	0.08	0.11	20.2	0.15	13,200	2.6		20.536044	0	0.004951
MPA-32	02/01/94	0.00	11:09	0.12	0.12	0.18	19.8	0.20	2,600	2.7		13.703724	1.38	
MPA-32	02/01/94	0.00	14:11	0.25	0.25	0.36	19.0	0.50	4,200	2.5				
MPA-32	02/01/94	0.00	16:10	0.33	0.33	0.48	18.0	0.70	4,800	2.8				
MPA-32	02/01/94	0.00	18:09	0.41	0.41	0.60	17.2	0.70	5,000	2.7				
MPA-32	02/01/94	0.00	22:10	0.58	0.58	0.84	16.0	0.80	4,800	2.4				
MPA-32	02/02/94	1.00	07:10	-0.04	0.96	1.38	14.1	0.85	4,600	2.8				
MPA-32	02/02/94	1.00	22:19	0.59	1.59	2.29	11.5	1.00	5,600	2.7				
MPA-32	02/03/94	2.00	16:50	0.36	2.36	3.40	8.7	1.50	6,400	2.9				
MPA-32	02/04/94	3.00	12:54	0.19	3.19	4.60	6.3	2.00	6,400	3.0				
MPA-24	02/01/94	0.00	10:09	0.08	0.08	0.12	19.0	5.90	6,400	3.0		19.498124	0	0.004788
MPA-24	02/01/94	0.00	11:12	0.12	0.12	0.18	18.5	5.90	6,000	2.8		12.891311	1.38	
MPA-24	02/01/94	0.00	14:13	0.25	0.25	0.36	18.2	6.00	6,000	2.7				
MPA-24	02/01/94	0.00	16:12	0.33	0.33	0.48	17.2	6.00	6,000	2.6				
MPA-24	02/01/94	0.00	18:12	0.42	0.42	0.60	16.5	6.00	5,200	2.6				
MPA-24	02/01/94	0.00	22:13	0.58	0.58	0.84	15.1	6.00	4,600	2.9				
MPA-24	02/02/94	1.00	07:12	-0.04	0.96	1.38	13.1	6.00	4,400	1.2	Bag almost empty.			
MPA-24	02/02/94	1.00	22:22	0.59	1.59	2.29	10.6	6.00	5,600	3.1				
MPA-24	02/03/94	2.00	16:52	0.36	2.36	3.40	8.3	6.20	6,000	2.3				
MPA-24	02/04/94	3.00	12:57	0.20	3.20	4.60	7.2	6.40	5,200	2.2				
MPB-39	02/01/94	0.00	10:12	0.08	0.08	0.12	18.3	0.15	1,900	2.3		19.764735	0	0.022065
MPB-39	02/01/94	0.00	11:14	0.13	0.13	0.18	15.5	0.20	3,600	2.8		6.5258231	0.6	
MPB-39	02/01/94	0.00	12:14	0.17	0.17	0.24	13.9	0.40	4,400	3.0				
MPB-39	02/01/94	0.00	14:15	0.25	0.25	0.36	11.0	0.50	5,400	2.2				
MPB-39	02/01/94	0.00	16:15	0.33	0.33	0.48	8.9	0.60	6,200	3.0				
MPB-39	02/01/94	0.00	18:14	0.42	0.42	0.60	7.3	0.70	6,600	3.0				
MPB-39	02/01/94	0.00	22:16	0.58	0.58	0.84	5.3	0.80	6,800	3.1				
MPB-39	02/02/94	1.00	07:16	-0.04	0.96	1.38	3.5	0.80	7,400	1.2	Bag almost empty.			
MPB-32	02/01/94	0.00	10:15	0.08	0.08	0.12	18.1	0.40	3,000	2.9		22.899696	0	0.03868
MPB-32	02/01/94	0.00	11:16	0.13	0.13	0.18	15.6	0.60	4,000	2.9		8.9749025	0.36	
MPB-32	02/01/94	0.00	12:18	0.17	0.17	0.24	14.1	0.90	4,800	2.6				
MPB-32	02/01/94	0.00	14:17	0.25	0.25	0.36	8.6	1.10	5,600	3.1				
MPB-32	02/01/94	0.00	18:17	0.42	0.42	0.60	6.9	1.40	5,600	3.0				
MPB-32	02/01/94	0.00	22:20	0.59	0.59	0.85	4.8	1.70	5,200	3.0				

MPC-39	02/01/94	0.00	10:20	0.09	0.09	0.13	13.1	1.50	11,200	2.7		16.564341	0	0.033539	
MPC-39	02/01/94	0.00	11:20	0.13	0.13	0.19	9.8	2.60	11,400	3.2		4.154811	0.37		
MPC-39	02/01/94	0.00	12:22	0.17	0.17	0.25	7.5	3.20	12,000	3.0					
MPC-39	02/01/94	0.00	14:20	0.25	0.25	0.37	4.8	3.60	12,400	2.8					
MPC-39	02/01/94	0.00	16:20	0.34	0.34	0.49	3.1	4.10	12,400	2.9					
MPC-39	02/01/94	0.00	18:20	0.42	0.42	0.61	2.6	4.50	11,600	2.9					
MPC-32	02/01/94	0.00	10:23	0.09	0.09	0.13	14.1	3.70	8,400	2.2		17.580384	0	0.034318	
MPC-32	02/01/94	0.00	11:22	0.13	0.13	0.19	10.4	4.10	10,800	2.9		4.8827683	0.37		
MPC-32	02/01/94	0.00	12:24	0.17	0.17	0.25	8.2	4.50	12,000	2.9					
MPC-32	02/01/94	0.00	14:23	0.26	0.26	0.37	5.5	5.00	12,000	2.7					
MPC-32	02/01/94	0.00	16:23	0.34	0.34	0.49	4.0	5.10	11,800	2.9					
MPC-32	02/01/94	0.00	18:23	0.42	0.42	0.61	3.1	5.10	11,200	1.9	Bag empty for Helium test.				
MPC-24	02/01/94	0.00	10:26	0.09	0.09	0.13	18.3	0.09	440	2.5		20.399212	0	0.020398	
MPC-24	02/01/94	0.00	11:25	0.13	0.13	0.19	16.3	0.10	1,720	2.4		7.9565002	0.61		
MPC-24	02/01/94	0.00	12:27	0.18	0.18	0.25	14.9	0.15	1,400	2.6					
MPC-24	02/01/94	0.00	14:25	0.26	0.26	0.37	12.6	0.15	1,840	2.7					
MPC-24	02/01/94	0.00	16:25	0.34	0.34	0.49	10.2	0.20	2,000	3.0					
MPC-24	02/01/94	0.00	18:25	0.42	0.42	0.61	8.3	0.15	2,400	2.9					
MPC-24	02/01/94	0.00	22:24	0.59	0.59	0.85	6.4	0.20	2,600	1.8	Out of sample on Helium test.				
MPC-24	02/02/94	1.00	07:22	-0.04	0.96	1.39	2.6	0.30	2,800	3.0					

Respiration Test
Oxygen and Helium Concentrations
Site 44, MPA-24
Nellis AFB, Nevada



Respiration Test
Oxygen and Helium Concentrations
Site 44, MPB-32
Nellis AFB, Nevada



NELLIS AFB - SITE 27
Biodegradation Rate Calculations

enter data	calculated data

Formula: $K_b = K_o \times 1/100\% \times A \times D_o \times C$ Where:

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density 1340 mg/L

C = Carbon/O_2 ratio for hexane mineralization = 1/3.5

Test Results: MPC-55

K_o = max. observed rate 0.000144 %/min.
w = moisture content 15.0 %

Assume: Soil properties for silty clay Specify from Table 1.4 (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

Porosity:	*n* =	0.45
Unit weight (dry):	$_g d$ =	1.43
Void ratio:	*e = n/1-n* =	0.82
Specific gravity:	G =	2.65

Calculate A = Air filled volume (V_a)/unit wt.
Solving for 1 liter of soil

a) $V_v = n * 1$ L
V_v = 0.45 liters V_v = void volume

b) $S_r = Gw/e$
S_r = 0.48 S_r = degree of saturation

c) $V_w = S_r \times V_v$
V_w = 0.22 liters V_w = volume of water

d) $V_a = V_v - V_{vw}$
V_a = 0.23 liters V_w = volume of water

e) Bulk density = $_g d + (V_w \times {_g w})$ = 1.7 kg/l soil

f) A = V_a/Bulk density = 0.135 l air/kg soil

$K_b = K_o \times 1/100\% \times A \times D_o \times C \times$ 525,600 min/yr = 40 mg TPH/year

BLOWER INJECTION SYSTEM DATA COLLECTION SHEET

SITE:________

DATE	TIME	INLET VACUUM (IN. WATER)	OUTLET TEMP. (DEGREES F)	OUTLET PRESSURE (IN. WATER)	FILTER CHANGED (Y or N)	BLOWER FUNCTIONING UPON ARRIVAL (Y or N)	COMMENTS	CHECKED BY

NELLIS AFB - SITE 27
Biodegradation Rate Calculations

enter data	calculated data

Formula: $K_b = K_o \times 1/100\% \times A \times D_o \times C$ Where:

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density 1340 mg/L

C = Carbon/O_2 ratio for hexane mineralization = 1/3.5

Test Results: MPB-55 — K_o = max. observed rate 0.000535 %/min.

w = moisture content 15.0 %

Assume: Soil properties for silty clay Specify from Table 1.4 (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

Porosity:	*n* =	0.45
Unit weight (dry):	$_g$d =	1.43
Void ratio:	*e = n/1-n* =	0.82
Specific gravity:	G =	2.65

Calculate A = Air filled volume (V_a)/unit wt.

Solving for 1 liter of soil

a) $V_v = n * 1$ L

V_v = 0.45 liters — V_v = void volume

b) $S_r = Gw/e$

S_r = 0.48 — S_r = degree of saturation

c) $V_w = S_r \times V_v$

V_w = 0.22 liters — V_w = volume of water

d) $V_a = V_v - V_{vw}$

V_a = 0.23 liters — V_w = volume of water

e) Bulk density = $_g$d + (V_w x $_g$w) = 1.7 kg/l soil

f) A = V_a/Bulk density = 0.135 l air/kg soil

$K_b = K_o \times 1/100\% \times A \times D_o \times C \times$ 525,600 min/yr = 150 mg TPH/year

NELLIS AFB - SITE 28
Biodegradation Rate Calculations

enter data	calculated data

Formula: $K_b = K_o \times 1/100\% \times A \times D_o \times C$ Where:

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density 1340 mg/L

C = Carbon/O_2 ratio for hexane mineralization = 1/3.5

Test Results: MPA-50

K_o = max. observed rate 0.004688 %/min.

w = moisture content 16.0 %

Assume: Soil properties for silty clay Specify from Table 1.4 (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

Porosity:	*n* =	0.45
Unit weight (dry):	$_gd$ =	1.43
Void ratio:	*e = n/1-n* =	0.82
Specific gravity:	G =	2.65

Calculate A = Air filled volume (V_a)/unit wt.

Solving for 1 liter of soil

a) $V_v = n * 1$ L

V_v = 0.45 liters — V_v = void volume

b) $S_r = Gw/e$

S_r = 0.52 — S_r = degree of saturation

c) $V_w = S_r \times V_v$

V_w = 0.23 liters — V_w = volume of water

d) $V_a = V_v - V_{vw}$

V_a = 0.22 liters — V_w = volume of water

e) Bulk density = $_gd + (V_w \times {}_gw)$ = 1.7 kg/l soil

f) A = V_a/Bulk density = / 0.129 l air/kg soil

$K_b = K_o \times 1/100\% \times A \times D_o \times C \times$ 525,600 min/yr = 1220 mg TPH/year

NELLIS AFB - SITE 28

Biodegradation Rate Calculations

enter data	calculated data

Formula: $K_b = K_o \times 1/100\% \times A \times D_o \times C$ Where:

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density 1340 mg/L

C = Carbon/O_2 ratio for hexane mineralization = 1/3.5

Test Results: MPC-40

K_o = max. observed rate 0.000875 %/min.

w = moisture content 26.0 %

Assume: Soil properties for silt and sand Specify from Table 1.4 (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

Porosity:	*n* =	0.45
Unit weight (dry):	$_g$d =	1.43
Void ratio:	*e = n/1-n* =	0.82
Specific gravity:	G =	2.65

Calculate A = Air filled volume (V_a)/unit wt.

Solving for 1 liter of soil

a) $V_v = n * 1$ L

V_v = 0.45 liters V_v = void volume

b) $S_r = Gw/e$

S_r = 0.84 S_r = degree of saturation

c) $V_w = S_r \times V_v$

V_w = 0.38 liters V_w = volume of water

d) $V_a = V_v - V_{vw}$

V_a = 0.07 liters V_w = volume of water

e) Bulk density = $_g$d + (V_w x $_g$w) = 1.8 kg/l soil

f) A = V_a/Bulk density = 0.039 l air/kg soil

$K_b = K_o \times 1/100\% \times A \times D_o \times C \times$ 525,600 min/yr = 70 mg TPH/year

NELLIS AFB - SITE 44
Biodegradation Rate Calculations

enter data	calculated data

Formula: $K_b = K_o \times 1/100\% \times A \times D_o \times C$ Where:

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density 1340 mg/L

C = Carbon/O_2 ratio for hexane mineralization = 1/3.5

Test Results: VW

K_o = max. observed rate 0.002465 %/min.

w = moisture content 20.0 %

Assume: Soil properties for silty clay Specify from Table 1.4 (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

Porosity:	n =	0.45
Unit weight (dry):	$_gd$ =	1.43
Void ratio:	$e = n/1-n$ =	0.82
Specific gravity:	G =	2.65

Calculate A = Air filled volume (V_a)/unit wt.

Solving for 1 liter of soil

a) $V_v = n * 1$ L

V_v = 0.45 liters V_v = void volume

b) $S_r = Gw/e$

S_r = 0.65 S_r = degree of saturation

c) $V_w = S_r \times V_v$

V_w = 0.29 liters V_w = volume of water

d) $V_a = V_v - V_{vw}$

V_a = 0.16 liters V_w = volume of water

e) Bulk density = $_gd + (V_w \times {}_gw)$ = 1.7 kg/l soil

f) A = V_a/Bulk density = 0.094 l air/kg soil

$K_b = K_o \times 1/100\% \times A \times D_o \times C \times$ 525,600 min/yr = 470 mg TPH/year

NELLIS AFB - SITE 44
Biodegradation Rate Calculations

enter data	calculated data

Formula: $K_b = K_o \times 1/100\% \times A \times D_o \times C$ Where:

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density 1340 mg/L

C = Carbon/O_2 ratio for hexane mineralization = 1/3.5

Test Results: MPC-32

K_o = max. observed rate 0.021384 %/min.

w = moisture content 10.5 %

Assume: Soil properties for silty clay Specify from Table 1.4 (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

Porosity:	n =	0.40
Unit weight (dry):	$_gd$ =	1.43
Void ratio:	$e = n/1-n$ =	0.67
Specific gravity:	G =	2.65

Calculate A = Air filled volume (V_a)/unit wt.

Solving for 1 liter of soil

a) $V_v = n * 1$ L

V_v = 0.4 liters V_v = void volume

b) $S_r = Gw/e$

S_r = 0.42 S_r = degree of saturation

c) $V_w = S_r \times V_v$

V_w = 0.17 liters V_w = volume of water

d) $V_a = V_v - V_{vw}$

V_a = 0.23 liters V_w = volume of water

e) Bulk density = $_gd + (V_w \times {_g}w)$ = 1.6 kg/l soil

f) A = V_a/Bulk density = 0.144 l air/kg soil

$K_b = K_o \times 1/100\% \times A \times D_o \times C \times$ 525,600 min/yr = 6200 mg TPH/year

NELLIS AFB – Site 27
Steady–state Equation – Air Injection

Enter data

Calculated data

$$k = \frac{Q\,\mu \ln(Rw/Ri)}{H\,\pi\,Patm\,[1 - (Pw/Patm)^2]}$$

Where:

Q = Volumetric flow rate of vent well

36.0	scfm x (30.48 cm/ft)^3 x (1 min/60 s) =	1.70E+04	cm^3/s

μ = Viscosity of Air @ 18° C =

		1.80E–04	g/cm s

Patm = Ambient pressure @ 3200 feet of elevation

364	inches H2O x (3.61E–2 psia/in. H2O) =	13.140	psia
13.140	psia x (6.89476E4 g/cm s^2)/psia =	9.06E+05	g/cm s^2

Rw = Radius of Vent Well

2	inches x 2.54 cm/in =	5.08	cm

H = Depth of Screen (length of screened interval)

25	feet x 30.48 cm/ft =	762	cm

Ri = Maximum Radius of Venting Influence

45	feet x 30.48 cm/ft =	1372	cm

Pw = Absolute Pressure at Vent Well

46	inches H2O x (3.61E–2 psia/in. H2O) =			1.661	psia
1.661	psia +	13.140	psia =	14.801	psia
14.801	psia x (6.89476E4 g/cm s^2)/psia =			1.02E+06	g/cm s^2

	k =	2.938E–08	cm^2
2.940E–08	cm^2 x (1 m/100 cm)^2 =	2.900E–12	m^2
2.900E–12	m^2 x 1 darcy/(9.870E–13 m^2) =	2.94	darcys

afbio4/3nell_ss.wk1/03–09–94

NELLIS AFB – Site 28
Steady–state Equation – Air Injection

Enter data

Calculated data

$$k = \frac{Q \mu \ln(Rw / Ri)}{H \pi Patm [1 - (Pw / Patm)^2]}$$

Where:

Q = Volumetric flow rate of vent well

32.5	scfm x $(30.48\ cm/ft)^3$ x (1 min/60 s) =	1.53E+04	cm^3/s

μ = Viscosity of Air @ 18° C = 1.80E–04 g/cm s

Patm = Ambient pressure @ 3200 feet of elevation

364	inches H2O x (3.61E–2 psia/in. H2O) =	13.140	psia
13.140	psia x (6.89476E4 g/cm s^2)/psia =	9.06E+05	g/cm s^2

Rw = Radius of Vent Well

2	inches x 2.54 cm/in =	5.08	cm

H = Depth of Screen (length of screened interval)

35	feet x 30.48 cm/ft =	1067	cm

Ri = Maximum Radius of Venting Influence

56	feet x 30.48 cm/ft =	1707	cm

Pw = Absolute Pressure at Vent Well

83.1	inches H2O x (3.61E–2 psia/in. H2O) =	3.000	psia
3.000	psia + 13.140 psia =	16.140	psia
16.140	psia x (6.89476E4 g/cm s^2)/psia =	1.11E+06	g/cm s^2

	k =	1.040E–08	cm^2
1.040E–08	cm^2 x $(1\ m/100\ cm)^2$ =	1.000E–12	m^2
1.000E–12	m^2 x 1 darcy/(9.870E–13 m^2) =	1.01	darcys

NELLIS AFB – Site 44
Steady–state Equation – Air Injection

Enter data

Calculated data

$$k = \frac{Q \mu \ln(Rw / Ri)}{H \pi Patm [1 - (Pw / Patm)^2]}$$

Where:

Q = Volumetric flow rate of vent well

36.0	scfm x $(30.48 \text{ cm/ft})^3$ x (1 min/60 s) =	1.70E+04	cm^3/s

μ = Viscosity of Air @ 18° C = 1.80E–04 g/cm s

Patm = Ambient pressure @ 3200 feet of elevation

364	inches H2O x (3.61E–2 psia/in. H2O) =	13.140	psia
13.140	psia x (6.89476E4 g/cm s^2)/psia =	9.06E+05	g/cm s^2

Rw = Radius of Vent Well

2	inches x 2.54 cm/in =	5.08	cm

H = Depth of Screen (length of screened interval)

25	feet x 30.48 cm/ft =	762	cm

Ri = Maximum Radius of Venting Influence

35	feet x 30.48 cm/ft =	1067	cm

Pw = Absolute Pressure at Vent Well

45	inches H2O x (3.61E–2 psia/in. H2O) =			1.625	psia
1.625	psia +	13.140	psia =	14.765	psia
14.765	psia x (6.89476E4 g/cm s^2)/psia =			1.02E+06	g/cm s^2

	k =	2.872E–08	cm^2
2.870E–08	cm^2 x $(1 \text{ m}/100 \text{ cm})^2$ =	2.900E–12	m^2
2.900E–12	m^2 x 1 darcy/(9.870E–13 m^2) =	2.94	darcys

APPENDIX B
O&M CHECKLIST

BLOWER INJECTION SYSTEM DATA COLLECTION SHEET

SITE:________

DATE	TIME	INLET VACUUM (IN. WATER)	OUTLET TEMP. (DEGREES F)	OUTLET PRESSURE (IN. WATER)	FILTER CHANGED (Y or N)	BLOWER FUNCTIONING UPON ARRIVAL (Y or N)	COMMENTS	CHECKED BY